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LIST OF PLATES.

PLATE		FACING PAGE
I.	Chalk Polyzoa	4
II.	Interior of Peristome in *Conulopsis*, *Echinocorys*, and *Echinocardium*	14
III.	Casts of Shells from the Suffolk Boxstones	20
IV.	,, ,, ,, ,,	21
V.	*Eocystis primæva*, Hartt	56
VI.	Chalk Polyzoa	100
VII.	Land-forms, Carnarvonshire	157
VIII.	Tertiary Foraminifera, New Guinea	211
IX.	,, ,, ,,	212
X.	George J. Hinde, F.R.S.	233
XI.	Leicestershire Dolomites	258
XII.	G. W. Lamplugh, F.R.S.	337
XIII.	Leaves of *Noeggerathiopsis*	292
XIV.	Great Erratic of Andesite, New Zealand	397
XV.	E. A. Newell Arber, M.A., Sc.D.	426
XVI.	British Carboniferous Goniatites	450
XVII.	Post-Larval Stages in Irregular Echinoidea	500
XVIII.	Basic Intrusions in Radnorshire	502
XIX.	Diabase intruded into Llandovery Limestone	504

LIST OF ILLUSTRATIONS IN THE TEXT.

PAGE

Diagrams of perignathic girdle in *Plesiechinus*, etc. 7
Diagram showing lines of mechanical stress productive of *Eocystis* plan of plate 52
Diagram map of S.W. Lincolnshire, showing position of exposures . 64
Hydraulic limestones of Owthorpe and Cotgrave Gorse 70
Transition bed and Middle Lias of Lincoln 105
Middle and Upper Lias of Yorkshire, Lincolnshire, and Northamptonshire 109
Diagram of Northampton Sands and Upper Lias 110
Sections of Newark District, Nottinghamshire 122
Profile of land surface near Tregarth 150
"Pliocene" plateau near Bangor 154
Shell-fragments described as Cirripede valves 170
Drawing of deer from cavern of La Peña 173
George Jennings Hinde, F.R.S. 236
Map of Leicestershire dolomites 252
Bouchardia minima, Thomson 260
Phreatoicus australis, Chilton 278
Phreatoicus wianamattensis, Chilton 279
Map of part of the London Basin 298
Map showing contours of Sub-Eocene and Sub-Pliocene Chalk . . 302
Section across part of the London Basin 304
Map of principal "dry" lakes, Western Australia 307
Locality map of southern portion of Western Australia 310
"Downend Chalk Pit" on Gallows Hill, Isle of Wight 353
William Lower Carter, M.A., F.G.S. 383
Map of Western Australia 386
Sketch-section of the Darling Range, Western Australia 391
Sketch-map of Lenham Bed, Diestien Sands, Louvain 411
Map showing Chalk surface contours, East Anglia 414
Calcite cleavage 424
Crustacean tracks in New Zealand Tertiaries 425
Anthracomya arenacea, Dawson 465
Euproops Amiæ, H. Woodw., sp. nov. 466
Head-shields of *Euproops Amiæ*, H. Woodw. 467
Bellinurus Trechmanni, H. Woodw., sp. nov. 471
Section of nodule showing plant-tissues 472
Yunnan Cystidea 508, 509, 534, 535
Hyæna salonicæ, n.sp. 541
Map showing mineral resources of Australia 545

THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE VI. VOL. V.

No. I.—JANUARY, 1918.

ORIGINAL ARTICLES.

I.—Notes on new or imperfectly known Cretaceous Polyzoa.

By R. M. Brydone, F.G.S.

(*Continued from the November Number, p. 496.*)

(PLATE I.)

VICARIOUS avicularia, that is to say avicularia substantially as large as zoœcia, have rarely been figured among the Cretaceous Cribrilinidæ, the only good instances I call to mind being *Escharipora incrassata*, D'Orb.,[1] *Membraniporella* (*Cribrilina*) *Falcoburgensis*, Perg.,[2] the illustration of which shows a clear case, although no reference is made to it in the text, and *Cribrilina ostreicola*, Bryd.[3] They are not, however, by any means so rare as this might suggest, and the four following species are probably not the only instances which will ultimately be added from the English Chalk.

Membraniporella Altonensis, sp. nov. (Pl. I, Figs. 1, 2.)

Zoarium unilaminate, adherent.

Zoœcia small, average length ·45 to ·5 mm. (exclusive of oœcium); side walls arched slightly inwards, front walls arched, arising without apparent break from the edges of the side walls and pierced by six pairs of radiating slits reaching from the edges nearly to the middle line; aperture semicircular, very simple, the posterior lip being apparently unthickened.

Oœcia occurring very regularly, helmet-shaped, with apertures cut well back.

Avicularia vicarious, with vaulted blister-like external walls; apertures shaped like a thermometer tube, with round bulb and straight stem; there is no raised rim round the bulb, but as it passes into the stem rims arise rapidly on either side and enclose the whole length of the stem, opening out into a small circle at the anterior end to admit a narrow internal front wall; as the surface of the beak is horizontal it stands out increasingly as the surface of the external wall descends anteriorly. Sometimes the beak is covered by an imperforate membrane. This species occurs very rarely in the zone of *H. planus* near Alton, Hants.

Membraniporella Shawfordensis, sp. nov. (Pl. I, Figs. 6, 7.)

Zoarium unilaminate, adherent.

Zoœcia of medium size, average length ·58 to ·62 mm.; the normal surface is obviously largely secondary; I have not seen any certain

[1] Pal. Crét. Franc., v, p. 223, pl. 685, figs. 2, 3.

[2] Bull. Soc. Belge Geol., 1893, p. 176 et seq., text-fig. 7.

[3] Geol. Mag., 1909, p. 399, Pl. XXIII, Figs. 1, 2.

instance of the primary stage, but it is probably represented in Fig. 7, and consists of zoœcia with distinct bluntly pyriporiform side walls, flatly arched front walls, pierced by five pairs of well-marked slits extending from the edge about a third of the way across, and a flatly semicircular aperture with slightly concave and upturned posterior lip formed by the broad unthickened margin of the front wall; the anterior end of the zoœcium rests on the rising external wall of the succeeding zoœcium, and thins out against it; small distinct avicularia are lodged in the interzoœcial depressions; in the secondary and normal stage the posterior lip of the aperture thickens and fuses completely with a pair of avicularia at the corners of the aperture and extends backwards a little way over the front wall in a blunt triangle and forwards on either side of the aperture on to the sides of and round the oœcium so as to form a platform level (except for the swelling due to the oœcium) and standing only slightly above the front wall in the middle line, but considerably above it at the sides, and encroaching on it more or less all round, but especially at the posterior end; the result of this encroachment is that only three of the pairs of slits usually remain visible and then only in reduced length; there is generally more or less of a depression in the centre of the anterior lip of the secondary aperture.

Oœcia invariably present in the secondary condition and evidently highly globose, but without any definite outline; aperture sunk below the general surface, so that its free edge is only partially visible.

Avicularia.—(*a*) Vicarious, average length ·55 to ·6 mm., scoop-shaped with approximately parallel side walls and rounded ends; the aperture appears to be bounded by the side walls in the posterior part, but anteriorly it tapers away and a narrow internal front wall appears; there are remains of a transverse bar across the posterior end of the aperture; they occur rather freely along the edge of the zoarium, and not infrequently in the body of the zoarium, where they are deeply sunk. (*b*) Accessory, in the primary condition apparently beak-shaped and distinct; in the secondary condition wholly merged in the general mass, leaving only the broadly arrow-head-shaped apertures visible; a pair occur very regularly at the posterior corners of the aperture and another pair much less regularly at the anterior corners.

This species is very rare; I have only seen one specimen, from the zone (restricted) of *A. quadratus* at Shawford, Hants. But for its vicarious avicularia it would form a very perfect link between *Membraniporella subcastrum*, Bryd.,[1] and *M. castrum*, Bryd.[2]

Membraniporella Bedhamptonensis, sp. nov. (Pl. I, Figs. 3–5.)

Zoarium unilaminate, adherent.

Zoœcia distinct, average length ·65 to ·7 mm.; side walls strongly overarching, front walls arising within the edges of the side walls, flatly arched and pierced by five or six pairs of very short, often

[1] *Ante*, p. 494.
[2] Geol. Mag., 1909, p. 398.

wide, and even triangular radiating slits; aperture horseshoe-shaped, posterior lip formed by the broad unthickened slightly upturned margin of the front wall, and uniting with the anterior lip to form a thin subtubular peristome.

Oœcia occurring freely but very erratically, relatively small, with rather narrow apertures cut slightly back.

Avicularia.—(*a*) Vicarious, average length ·6 mm., with beaks of the hour-glass type, but scoop-shaped, with almost parallel side walls hardly folded over or constricted at all in the middle or expanded at the ends; the posterior end of the beak is tilted up on a strongly inflated external wall; the aperture is long and narrow with rounded ends, the posterior end being bluntly rounded and enclosed by a very narrow internal front wall, and the anterior end tapering somewhat and being enclosed by a wide internal front wall. (*b*) Accessory, small roundish lumps with arrowhead-shaped apertures standing up high and possibly sometimes supported on slender legs like those of *M. Sherborni*, Bryd.[1]; very abundant, grouped thickly round the apertures, sometimes as many as four to an aperture, but very rare away from the apertures. The vicarious avicularia are very erratic in occurrence, and do not seem to appear until the zoarium has reached a fair age, so that they can only be expected at the edges, if at all, in small or medium-sized zoaria.

This species seems to be coeval with *M. manonia*, Bryd.,[2] and like it very characteristic of and restricted to the lower part of the zone of *B. mucronata* in Hants and the Isle of Wight.[3] It has been found at the very base of that zone at Bedhampton, Hants, but never yet in the zone of *A. quadratus*. It forms a very natural introduction to

MEMBRANIPORELLA TRIMENSIS, sp. nov. (Pl. I, Figs. 8–10.)

Zoarium unilaminate, adherent or free.

Zoœcia large, average length ·9 to ·95 mm., distinct, decidedly pyriporiform; front walls arched, arising at an angle from the edges of the side walls, and pierced by about four pairs of short, broad, and sometimes triangular slits, with a broad band separating the uppermost pair of slits from the aperture and merging at its ends imperceptibly into the side walls; aperture typically about five-eighths of a circle, with a short, straight, posterior lip, but rather variable in shape; posterior lip short and straight with a slightly upturned edge, which sometimes develops into a median denticle, and combines with the anterior lip produced upwards and slightly

[1] Ibid., 1906, pp. 289–300, Fig. 7 (as *Cribrilina Sherborni*).

[2] *Ante*, p. 146.

[3] There is a very similar form in the Weybourne Chalk, in which according to my only good specimen the front wall has the slits usually obliterated by calcification, the aperture is very irregular in shape and sometimes sharply triangular owing to the encroachment of the accessory avicularia, the accessory avicularia are only slightly prominent, and the vicarious avicularia are longer and wider and expanded at the anterior end, being of the same general outline as those of *Membranipora invigilata*, Bryd. (GEOL. MAG., 1910, p. 76), and the remains of the transverse bar are much more pronounced. I should not care to commit myself to its being a distinct species on practically one specimen, but if so it might be named *M. Weybournensis*.

forwards into a thin subtubular peristome. There is a tendency for a roof to arise along the interzoœcial furrows and spread over the posterior ends of the zoœcia.

Oœcia very scarce, large, and very globose; aperture narrow, vertical.

Avicularia.—(*a*) Vicarious, very large, up to 1 mm. in length, of hour-glass type, with very round anterior ends and side walls sloping outwards in the middle; apertures rounded posteriorly and almost pointed anteriorly, with a large area of internal front wall in the anterior bulb of the hour-glass and a considerable amount in the posterior bulb; there is a thick transverse bar just below the area of constriction. (*b*) Accessory, small beak-shaped or rounded masses raised above the general surface apparently on slender legs as in *M. Sherborni*, Bryd. (*ante*), and scattered in great abundance along the interzoœcial furrows, while sessile specimens encroach very freely on the broad posterior lip of the aperture.

This very fine species occurs sparingly in the Trimingham Chalk.

EXPLANATION OF PLATE I.

(All figures × 12 diams.)

Fig. 1.—*Membraniporella*	*Altonensis.*	Zone of *Holaster planus*, near Alton, Hants.
,, 2.	,,	,,	Another part of the same specimen showing closed avicularia.
,, 3.	,,	*Bedhamptonensis.*	Zone of *B. mucronata*, Bedhampton, Hants. From the margin of a large zoarium.
,, 4.	,,	,,	Part of the interior of the same zoarium.
,, 5.	,,	,,	Part of a zoarium in which no avicularia have developed.
,, 6, 7.	,,	*Shawfordensis.*	Zone of *A. quadratus*, Shawford, Hants.
,, 8–10.	,,	*Trimensis.*	Zone of *B. mucronata*, Trimingham. Different parts of the same zoarium. No. 10 shows an oœcium slightly confused with a perfect avicularium.

II.—Morphological Studies on the Echinoidea Holectypoida and their Allies.

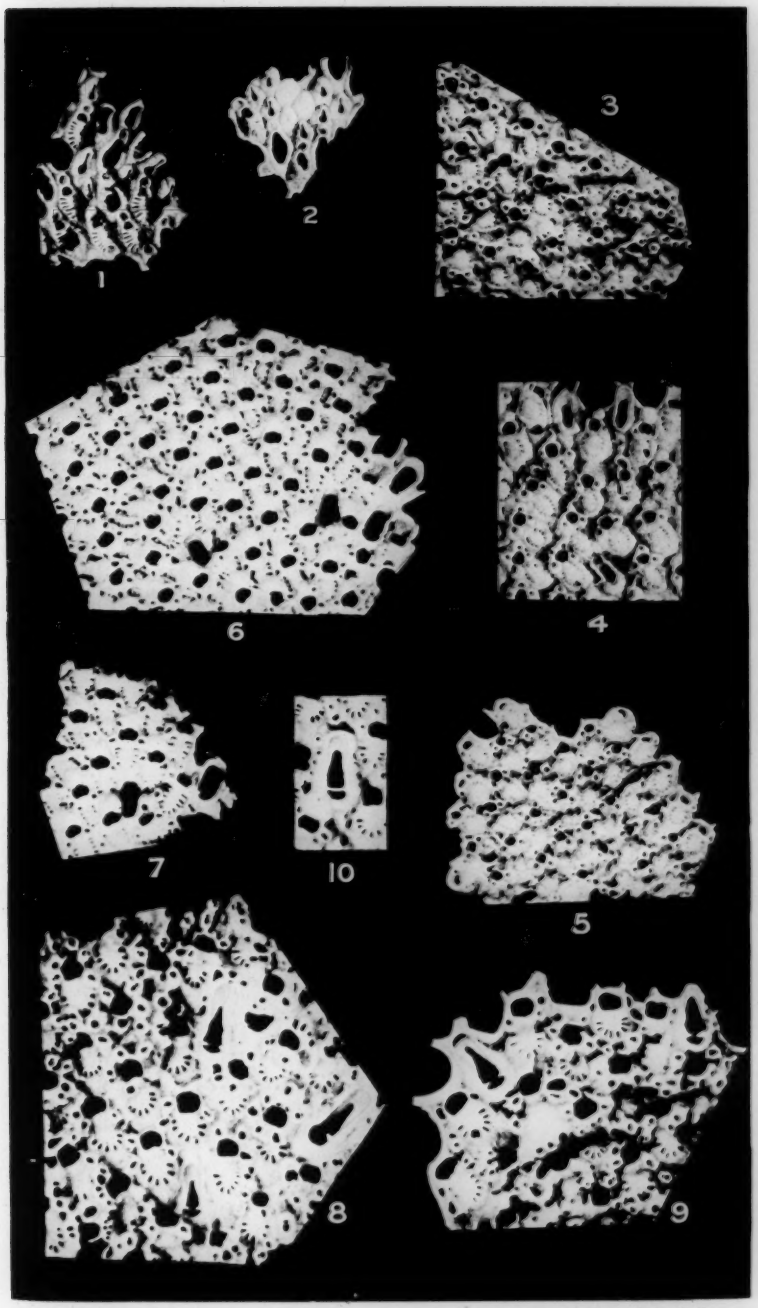
By Herbert L. Hawkins, M.Sc., F.G.S., Lecturer in Geology, University College, Reading.

VII. The Perignathic Girdle of the Holectypoida and the Corresponding Structures of other Irregular Echinoidea.

(PLATE II.)

1. Introduction.

In the three preceding papers of this series descriptions have been given of the perignathic girdles of familiar representatives of the three families into which the Holectypoida are at present divided.



R. M. Brydone, Photo. *Benrose & Sons Ltd., Colls.*

Chalk Polyzoa.

From the scanty evidence available, it would appear that in respect of this structure *Plesiechinus* is typical of the Pygasteridæ (even including *Anorthopygus*). The girdle of *Holectypus* seems essentially similar, thereby differing from that of the Discoidiinæ; but as yet the perignathic structures of the Cretaceous *Coenholectypus* are unknown. Large species of *Discoides* have girdles differing in proportions only from those of the smaller forms, typified by *D. subuculus*. In default of further knowledge, the development of the girdle in *Conulus albogalerus* may be considered to be that characteristic of the genus and family. It is thus possible to summarize the known features of the girdle of the Order with some confidence, and to discover the "common denominator" of its varied characters. Stripped of its diverse additions, the girdle is found to present a uniform and practically unvaried structure which may be regarded, from the systematic standpoint, as being a diagnostic feature of the Order.

The primitive and conservative nature of the Holectypoida among Irregular Echinoids has been so often indicated, and indeed is so manifest, that it may be taken for granted without further argument. It follows from this that there are but two alternative possibilities for the lines of descent of all other Orders of the Sub-Class. Either they must have arisen from some "Regular" stock independently of the Holectypoida, in which case they need show no special resemblances to that group save under the influence of parallelism of development; or else they must have descended directly or indirectly from Holectypoid ancestors. In the present paper a brief description of the peristomial characters of certain representative Irregular Echinoids is given, and an attempt is made to indicate the presence or absence of relationship to the Holectypoida shown by this fragment of evidence. The genera whose internal test-structure has been examined for this purpose are *Clypeaster*, *Echinocyamus*, and *Echinarachnius* among the Clypeastroida, *Nucleolites* and *Trematopygus* among the "Nucleolitoida", *Conulopsis* among the ?Cassiduloida, and *Echinocorys*, *Micraster*, and *Echinocardium* among the Spatangoida. In the case of the first and last mentioned Orders, the genera studied may be taken as fairly representative of the groups to which they belong; but the other two Orders (usually grouped together under the name here restricted to the latter) are very imperfectly illustrated. This is accounted for by the extreme difficulty of the preparation of the Jurassic forms and the virtual impossibility, under existing circumstances, of acquiring suitable material of the *Cassidulus–Echinolampas* series, which are almost unrepresented in the British fauna, both past and present.

On stratigraphical evidence it is at least possible to regard the Nucleolitoida (including such genera as *Nucleolites*, *Clypeus*, and *Pygurus*) as "cousins" or even "brothers" of the Holectypoida, rather than as their lineal descendants. If this should prove to be the case an interesting illustration of parallelism would appear. The Holectypoida are first found in the Lias, occur in abundance throughout the succeeding stages of the Mesozoic, and are represented in the Tertiary and Recent faunas only by the apparently degenerate

types of *Echinonëus* and *Micropetalon*. The Nucleolitoida similarly make their first appearance in the Lias, were extraordinarily abundant and varied in the later Mesozoic, and are reduced at the present day to a solitary and very simple representative of their least specialized family, the Nucleolitidæ. The time of the first occurrence affords no indication of the ancestry of the other three Orders of Irregular Echinoids; and the approximate synchronism of their differentiation, while suggestive of a common origin, may well be but another expression of the parallelism above indicated. Although evidence derived from the study of one series of structures affords no sound basis for the erection of a scheme of phylogeny, it is none the less profitable to examine it as an index of morphogenetic affinity. If the prevalent view of the irreversibility of evolution is correct, such indications should at least show which lines of descent are *impossible*, and so narrow down the limits of probability, which may be further restricted by similar arguments founded on the observed characters of different sets of structures. It will be in this sense that suggestions as to the phyletic affinities of the various forms studied will be put forward in this paper.

2. The Holectypoid Girdle.

(a) *The persistent elements of its structure.*

Although the perignathic girdles of *Plesiechinus* and *Conulus* appear to be essentially dissimilar on a casual inspection, the reverse seems to be the truth. If the distinction between the "true" and "false" ridges of the girdle, which I have argued in the two preceding papers, is accepted, the differences between the characters of the "genuine" girdle in the two genera prove to be of so insignificant an order that they would hardly excite surprise if occurring in two species of a single genus. The accompanying diagram (Text-fig. 1), in which the three best-known girdles of the Holectypoida are associated (together with the two chief types of Clypeastroid girdle), shows this fundamental identity more clearly than verbal description could suggest. In the diagram the buttresses and false ridges (where present) are drawn in outline, while the true elements of the girdle, both ridges and processes, are blocked in. The undifferentiated parts of the corona are indicated by shading. The conservatism of the Order could nowhere be expressed more emphatically than by the retention of so physiologically important a structure throughout the Jurassic and Cretaceous stages with hardly appreciable change.

The essential characters of the perignathic girdle of the Order Holectypoida may be thus described:—

Ten lath-like processes spring in pairs from the proximal ambulacral plates, and are inclined outwards from the vertical axis. For the greater part of their length the pairs diverge slightly (i.e. slope away from the perradial line), but at their distal ends they may converge to a small extent (i.e. *Discoides*), never sufficiently to produce even the semblance of an arch or "auricle". The processes are supported by variously placed and diversely developed buttresses, but are always separated from these by a defined suture, and are composed of more compact stereom.

Five very small ridges occupy the inner surfaces of the proximal (unpaired) interambulacral plates, never extending beyond the limits of the latter. They are crescentic in plan, have a various sculptured surface, and are always separated from the processes by a space at least as great as their breadth. They may be entirely free (*Plesiechinus*), or may become more or less involved in the buttresses when these tend to encircle the peristome (*Discoides* and *Conulus*).

These two sets of structures, according to my belief, are the only ones concerned with the attachment of the jaw-muscles, and so constitute the true perignathic girdle. All other structures entering into the "peristomial ring" are variously swollen portions of the normal plates, adapted for the mechanical support of the processes, the jaws, or the buccal plates (or in some cases of all three sets of ossicles), or for the greater strength of the invaginated part of the corona which encloses the peristome. The true perignathic girdle retains very constant proportions from Liassic to Upper Cretaceous times, its only noteworthy change consisting of a progressive tendency towards increased obliquity in the setting of the processes.

The Holectypoid girdle, as thus restricted, is extremely primitive. As regards the processes, it represents a phase reproduced only in the early post-larval ontogeny of recent Diademoida, and there is some reason to believe that the ridges of non-Cidaroid Regular Echinoids are first developed on the unpaired interambulacral plates. The inference may be drawn that the Holectypoida sprang from a Regular stock at a stage when the perignathic girdle had barely progressed beyond the early Cidaroid phase, and that, unlike most of their Diademoid relatives, they failed to improve upon the almost phylembryonic structure with which they were endowed.

(b) *The perignathic buttresses.*

In all of the Holectypoida whose perignathic girdles are known, the processes are supported by buttresses which rise from the inner surface of the test. These supports are demonstrably parts of the actual coronal

FIG. 1.—Diagrams of the perignathic girdle in A, *Plesiechinus*; B, *Discoides*; C, *Conulus*; D, *Clypeaster*; E, *Echinarachnius*. The elements of the true girdle are black, the false ridges (in B and C) in outline, and the normal coronal plates shaded. The figures represent the girdle viewed from the peristome laterally, drawn on "Mercator's Projection". The proportions of the various parts are not accurately shown, all the figures being brought to the same size.

plates, being crossed by transverse sutures, and they can be distinguished from the actual elements of the girdle by their less polished surfaces and open stereom-mesh in direct continuity with that of the plates from which they rise. In Jurassic forms, and apparently in their nearest relatives in the Cretaceous period, the buttresses are short and steep ridges which radiate for a varying distance near to or upon the adradial sutures. In *Discoides* the same series of radiating ridges can be recognized, although they are reinforced by others of a similar trend and by a circular region of elevation surrounding the peristome. In *Conulus*, where the whole inner adoral surface of the interambulacral area is much thickened, no separate buttresses can be distinguished; each area may, however, be regarded as being lined by a fused and extended mass of buttresses.

The apparently universal presence of this adambital support for the processes is almost peculiar to the Holectypoida. The girdles of the Cidaroida and Diademoida are sufficiently strong in themselves to stand without additional help; those of the Clypeastroida, though often relatively slender, are so encompassed by the ridges and pillars which cross the test-cavity that they seem to be equally independent, in most cases, of special buttresses. This contrast is suggestive of some special relation between the perignathic girdle and the jaws in the Holectypoida wherein they differ from the other gnathostomatous Orders. Perhaps it may be connected with the undoubtedly "flaring" character of the lantern. In the Regular Orders the jaws are almost vertical, and their weight can best be supported by a "sling" of muscles, on all of which the "pull" would be almost vertically downwards. In the Clypeastroida the jaws are practically horizontal in typical forms, and they almost articulate with the processes. The onus of their support will be shared between the adoral surface of the test and the processes, the strain on the latter acting again vertically downwards. But with a lantern inclined at, say, 45° from the vertical (and a girdle correspondingly splayed), the downward weight would tell upon the lath-like processes obliquely, so that they would require to be strengthened from below and without to prevent fracture. In support of this suggestion it may be recalled that in those Clypeastroids in which the lantern is elevated above its normal prostrate position, the processes have adambital keels similar in many respects to those of *Plesiechinus*.

Although the buttresses are obviously, and probably originally, connected with the mechanism of the perignathic girdle, they assume a more far-reaching function in the Cretaceous Holectypoida and their Clypeastroid descendants. The adoral regions of the test in both Orders is normally very thin, so that the peristomial invagination, as well as the sharply reflexed ambital margin, demand a girder-like support. In the Jurassic forms, the latter line of weakness is not seriously developed, and the buttresses in consequence are restricted to the central part of the surface, in the region of the invagination of the peristome. In *Discoides* the ambital margin is angular rather than curved, so that the girders are extended across that fragile zone. In *Conulus*, although the ambitus may be

as acute as in *Discoides*, the general thickness of the test makes unnecessary the prolongation of such carinate buttresses. In the Clypeastroida, where the angle between the adoral and adapical surfaces of the test is often very acute (e.g. *Echinarachnius*), a bewildering profusion of essentially buttress-like structures is developed. It is worthy of note that in those Clypeastroids which have a moderately rounded ambitus (e.g. *Echinocyamus*) the buttresses are for all intents and purposes retained in the relatively simple "*Discoides*-phase".

The buttresses may be considered to have been developed primarily as supports for the inclined elements of the perignathic girdle, and to have acquired a secondary function as joists, girders, or rafters for the strengthening of the test-fabric. This secondary function is retained, and carried to an almost excessive degree of specialization, in the typical Clypeastroids, where the primary purpose of the buttresses has disappeared, and their original positions are abandoned.

3. The Clypeastroid Girdle.

It is unnecessary to describe in detail the well-known characters of the girdle of the Clypeastroida. Students may be referred to the exquisite drawings and detailed descriptions in Lovén's *Echinologica*; or, for a general summary, to Jackson's *Phylogeny of the Echini*. It will be sufficient here to indicate the analogies between the various types of Clypeastroid girdle with that of the Holectypoida, and to indicate the probable relations between them.

The Clypeastroid girdle seems to consist of processes only. These processes are always approximated to one another in pairs near the interradial line, and in many groups are fused into a single, though often visibly compound, element. Their interradial convergence is rendered possible by the reduction in width of the interambulacra as they approach the peristome, and by the actual extension of the ambulacral plates, whereby they sometimes meet internally across the interradius, more or less completely ousting the proximal interambulacral plate from participation in the lining of the test-cavity. The processes may, however, transgress on to the proximal interambulacral plate when this is well represented, this anomaly being usual where the processes are fused.

In *Echinocyamus*, a genus usually regarded as showing arrested evolution, and approximating to the *Discoides subuculus* group of the Holectypoida, the perignathic girdle is found to be exceptionally specialized. Superficially regarded, it certainly appears like that of *D. subuculus*, especially since it is buttressed up by the thickening of the interambulacral plates, and the floor of the test is traversed by carinæ. But each section of the girdle consists of a fused pair of processes which are based entirely on the interambulacrum. There seems every reason to believe that the girdle does actually consist of transposed processes, but there is no proof of the existence of a ridge, whether true or false, included between them. It is certainly questionable whether such a development can be considered primitive, in comparison with that of such a form as *Clypeaster*. Probably the

two types of girdle characterize independent lineages. *Echinocyamus* (and the Scutellidæ) may perhaps claim the small *Discoides* as their ancestors, while the genealogy of *Clypeaster* leads back through *Conoclypus* to such a type as *Discoides cylindricus*.

The essential difference between the Holectypoid and Clypeastroid girdles lies in the apparent absence of any originally interradial element in the latter. This element is, however, so persistently minute in the Holectypoida that its suppression would be a slight modification when compared with other morphological changes introduced in the Tertiary Order. In the Clypeastridæ, the virtual exclusion of the interambulacral plates from the inner rim of the peristome renders the change inevitable. In the *Echinocyamus* series the fusion of the two transposed processes would tend to crush the ridges out of existence, although it is at least conceivable that some trace of them may remain in the middle of each compound "auricle". Except in the family of the Fibulariidæ, the neighbourhood of the peristome is practically free from structures due to secondary thickening, so as to allow free play for the recumbent lantern. There is thus no reason nor opportunity for the development of a false ridge. The processes of *Clypeaster* are upheld by carinæ recalling those of *Plesiechinus*.

If the false ridges of *Discoides* or *Conulus* were removed (or laid parallel with the floor of the test), and the already almost negligible true ridges abandoned, the resulting girdle would be, for all intents and purposes, that of the Clypeastridæ. Further knowledge of the ontogeny of the girdle of the Fibulariidæ, Laganidæ, and Scutellidæ is needed before a definite opinion can be formed as to the origin of the interradially placed fused "auricle". As far as appears at present, this could have been produced either by the convergence of the isolated processes of a Clypeastrid, or independently by an interradiad encroachment of the processes of an Holectypoid upon the ridges, resulting in the destruction or incorporation of the latter. In any case it seems clear that both types of Clypeastroid girdle can be regarded as modifications of that of the Holectypoida.

4. The Nucleolitoid Peristome.

The following section is based upon an examination of twenty-seven specimens of *Nucleolites scutatus* from the Corallian of Marcham, near Abingdon, and of two examples of *Trematopygus* from the Faringdon Greensand. These are the only forms of this Order in which I have as yet succeeded in exposing the interior of the test. Serial sections through the adoral regions of a specimen of *Galeropygus agariciformis* and two of *Clypeus sinuatus* seem to show no serious difference in this character from the smaller and more satisfactorily studied genera.

The greater part of the test of the adoral surface of most Nucleolitidæ is very thin, and the peristome is markedly invaginate. (An exception to this rule occurs in those forms which have the beginnings of a floscelle developed.) Seen from within the peristome it resembles a truncated and obscurely pentagonal hollow cone. The interambulacral parts of the margin are quite obviously thicker than the ambulacral, and than the rest of the adoral part of the test.

But this locally thickened region is merely a rim, and no trace of any structure even remotely suggestive of a perignathic girdle can be detected in it. It is not undercut adambitally, but is imperceptibly reduced to the average thickness before the invagination is passed. The ambulacral part of the peristome border is remarkably thin, and shows absolutely no indication of any kind of specialization. It is simply the inverted edge of the proximal ambulacral plates. There is thus no vestige of a perignathic girdle in the observed genera of this Order.

The complete and sudden disappearance of the jaws and everything pertaining to them in the Nucleolitoida is mysterious, but by no means surprising. Before the advent of the Oolitic period, while yet the Diademoida and Holectypoida had hardly entered upon the paths of the evolution of their buccal structures, the Nucleolitoida had utterly abandoned all traces of such apparatus. An ontogenetic parallel is afforded by the young *Echinonëus*, in which a lantern and girdle are almost completely developed, both disappearing simultaneously at a later stage of growth. In the absence of any development capable of correlation with the perignathic girdle, it is impossible to make comparisons between the Nucleolitoida and the Holectypoida. But the complete diversity of the two Orders in this respect, coupled with their contemporaneous and early appearance, suggests that they originated independently. Whether they sprang from a common stock or are fundamentally distinct, is a problem which cannot be attacked on these lines of argument.

5. The Cassiduloid Peristome.

I have examined the interior of the peristomial region in *Conulopsis* (*Echinoconus*, Desor) only among the many representatives of this Order. The evidence thus obtained, though interesting and suggestive, cannot therefore be considered adequate for the formulation of any definite hypothesis. It seems, however, sufficient to indicate the phyletic distinction between this Order and the Nucleolitoida, with which it is generally associated.

Externally, the adoral region in this Order is characterized by the expansion of the proximal parts of the ambulacra into variously developed phyllodes, separated from one another by more or less prominent "bourrelets" on the interambulacra. (Many of the more elaborate Nucleolitoida, such as *Clypeus* and *Pygurus*, are similar in this respect.) Internally, the thickening of the interambulacra is almost like a reflection of their external character, so that the interradial margins of the peristome are excessively massive.

In *Conulopsis abbreviata*, from the Upper Chalk of Norfolk, the phyllodes are practically non-existent, although pronounced "bourrelets" are developed. An internal view of the adoral surface shows a remarkable resemblance to that seen in *Conulus*, and is of itself enough to render the generic name morphologically appropriate, whatever may be its systematic fate. The ambulacra are terminated adorally by an almost unthickened edge, and so appear as five grooves radiating from the slightly elliptical aperture of the peristome. The interambulacra increase steadily in thickness from the ambitus almost

to their proximal termination, and are then steeply bevelled off by a pair of concave bays or "combes", between which the areas project as rounded spurs almost overhanging the slope of the "escarpment". The two "combes" in each area are most deeply excavated just on the interradiad side of the adradial sutures. Here they appear as deep slots, differing only in proportion from the hollows in the false ridges of *Conulus*. By analogy, it would seem that these hollows in the peristomial margin of *Conulopsis* must have been destined to receive massive buccal plates when the mouth was opened.

Unless *Conulopsis* is on a side line of evolution, it would appear to be a simple member of the Caratomidæ, and as such more or less ancestrally related to the *Echinolampas*-group. Whatever be its other affinities, it must surely be nearly related to *Conulus*, to judge from the nature of most of its test-structures. As far as the perignathic girdle is concerned, it may be considered to show the retention of the false ridges of *Conulus*, after the loss of both sets of the "true" elements of the girdle. From the scanty evidence at my disposal, I believe that *Catopygus*, a far more "advanced" type of Cassiduloid, has a similar perignathic structure. Clarke & Twitchell (*The Mesozoic and Cenozoic Echinodermata of the United States*) give figures of internal moulds of *Cassidulus californicus* (pl. lxv) and *Pygorhynchus gouldii* (pl. lxxix) which show a strong interradial thickening of the interior of the test at the peristome in these typically Cassiduloid species.

6. The Spatangoid Peristome.

For the present purposes I have examined the interior of the test in many examples of *Echinocorys*, *Micraster*, and *Echinocardium*.

The predominant feature of the peristome of the Spatangoida is its progressive adaptation to the requirements of a burrowing life and an "earthworm" mode of feeding. The part of the aperture bounded by interambulacrum 5 comes to project below the general level of the adoral surface, and its margin develops into a spoon-like labrum. All Spatangoids, as far as is known, are entirely destitute of jaws. MacBride has recognized as teeth certain spicules produced at a very early stage of post-larval ontogeny, but no pyramid or auricular vestiges seem to be associated with them, and they disappear shortly after their formation.

Klinghardt has identified as "auricles" certain protuberances at the side of the peristome in *Echinocorys*, but the examination of considerable numbers of specimens of *E. vulgaris*, representative of many of the later growth stages, has convinced me that these blunt excrescences are not processes (being based upon the interambulacra), so that they can hardly be homologous with any part of a perignathic girdle in the strict sense of the term.

Reference has been made in the preceding article of this series to the curious "mode" of excessive stereom-formation prevalent among the Echinoids of the Cretaceous period. The early Spatangoids almost universally adopted this character, so that the margins of their peristomes are always of considerable thickness. This applies

particularly to the anterior and posterior edges of the aperture. The thickness is always greater in the interambulacral parts than in the ambulacral. Save on the edge of the labrum, there is no indication that the thickened margin is adapted to any special requirement beyond that of strengthening the free edge of the corona. In the case of area 5, the lip is often rolled over away from the peristome, and overhangs the "bowl" of the spoon-like labrum to a slight extent. In the (presumably) more primitive types, where the labrum is hardly worthy of the name (e.g. *Echinocorys*) there is no trace of such a specialization of the margin, which is merely thickened similarly to, but in a less degree than, the other interambulacral edges; it must consequently be a secondary development suited to the needs of a labrum, and can have no homology with the perignathic ridges of less specialized groups. On the thickened margins of areas 2 and 3, in *Echinocorys* and *Micraster*, the line of attachment of the buccal membrane is often apparent. Within this the secondarily thickened margins rise almost vertically, and seem to show no feature inconsistent with the belief that they are simply the truncated edges of the coronal plates. They certainly constitute "false ridges", but whether they are to be correlated with those of the Holectypoida is very doubtful.

In most of the Recent Heart-Urchins there is a more or less extensive alar projection from interambulacrum 4 near the margin of the peristome. In many forms a corresponding, but only just visible, projection occurs in area 1. These projections afford support for the mesenteries holding the proximal parts of the alimentary canal. They have been regarded by some authors as modifications of parts of a perignathic girdle. The only fossil in which I have succeeded in recognizing even a trace of such a projection is a *Schizaster* from the ? Miocene of East Africa. The extreme delicacy of the free part of the structure is such that only its foundations could be hoped for under the conditions of fossilization. It is possible that the presumed "auricles" described by Klinghardt in *Echinocorys* may represent such a structure, though they seem to be somewhat sporadic and irregular in their occurrence. But I have never seen a trace of these projections in any Cretaceous Spatangoid. As far as my experience goes, these œsophageal supports are a recent development restricted to fully specialized Heart-Urchins, and so are not likely to be homologous with any part of a true perignathic girdle.

As at present known the peristomial characters of the Spatangoida give no satisfactory clue to their morphogenetic relationships, while their more elaborate features are purely secondary developments, quite unconnected with any ancestral qualities.

7. Summary.

The perignathic girdle of the Holectypoida is believed to consist of disjunct processes situated almost on the adradial sutures, with minute "true ridges" occupying the inner surfaces of the unpaired interambulacral plates. This character is constant throughout the group, although it may be partly obscured by the development of

"false ridges" due to requirements of mechanical strength and to the phenomenon of "super-calcification". The girdle, apart from such modifications, is shown to be essentially primitive—more so than that of any modern Diademoids.

By the default of the proximal interambulacrals, or by an actual transgression of the processes, the ridges are wanting in the Clypeastroida, and the processes converge towards the interradial line, often fusing in pairs. Such a character may readily have been derived from the Holectypoid girdle. The presence of so great a complexity of internal buttresses in the Clypeastroida points to their derivation from some Cretaceous representative of the Holectypoida, in which series alone such structures are strongly developed.

The *Nucleolites* series of Jurassic so-called Cassiduloida (here styled Nucleolitoida) seem to possess no trace of a perignathic girdle, even in the simpler and early forms. The sudden disappearance of the apparatus (there can be hardly any doubt that the ancestors of all Enechinoida were gnathostomatous) seems to point to the conclusion that the Nucleolitoida arose independently of, but contemporaneously with, the Holectypoida.

The Cassiduloida, to judge from the characters of one of the least specialized forms, *Conulopsis* (and, I believe, from those imperfectly known in *Cassidulus* itself), have a much thickened peristome in which there is a strong resemblance to that of *Conulus*, although the actual ossicles of the girdle are wanting. It is suggested that the false ridges are retained in this group, which becomes thereby affiliated to the *Conulus* series of the Holectypoida.

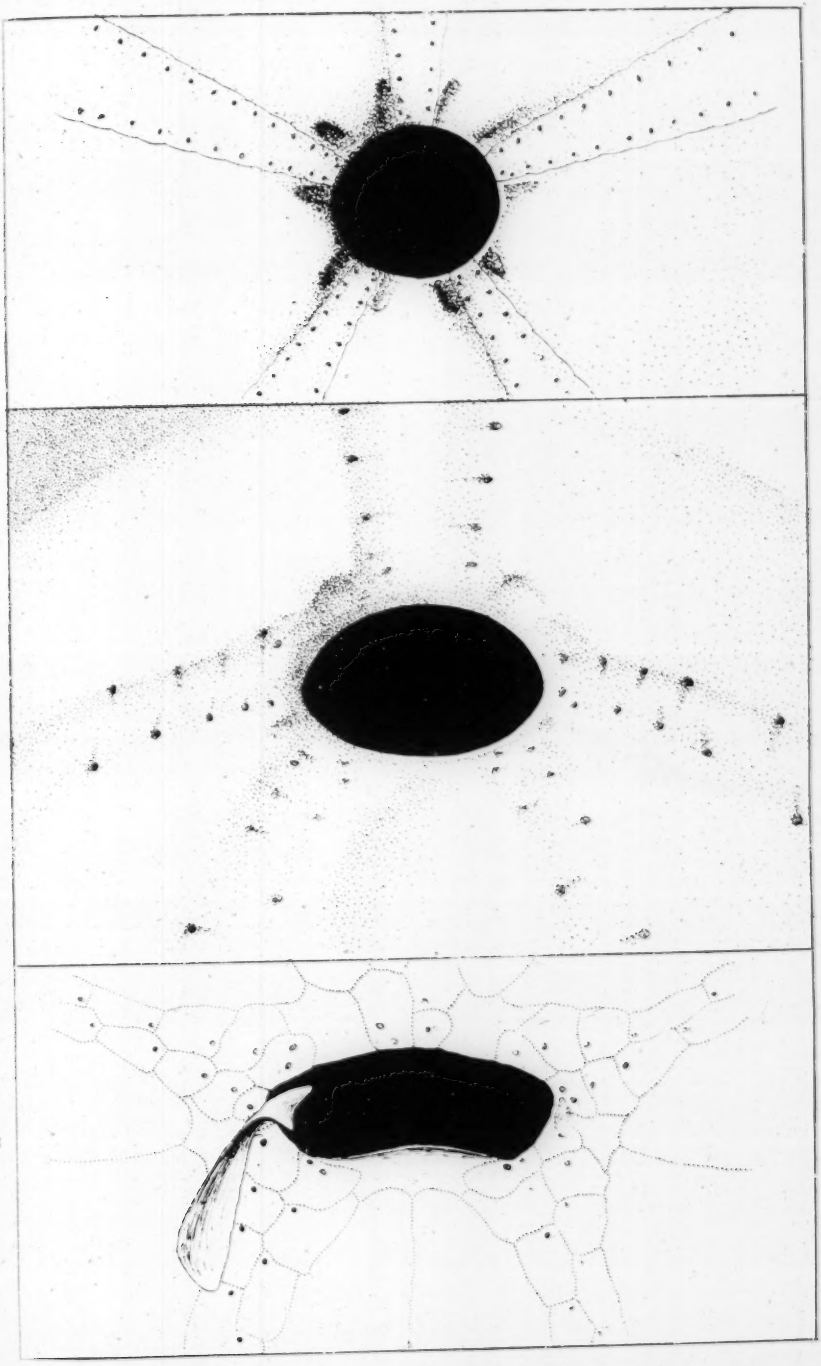
The Cretaceous Spatangoida have much thickening of the peristomial plates, especially in the anterior region, but it has not been possible to correlate any of their structures with the girdle, true or false, of the Holectypoida. The œsophageal support developed on one or both sides of the peristome in the later Heart-Urchins is regarded as an entirely secondary structure, with no affinity to any portion of a perignathic girdle.

EXPLANATION OF PLATE II.

FIG. 1.—Interior of peristome of *Conulopsis abbreviata*. × 6. The floor of the test is thickened in the same manner as that of *Conulus*, and deep slots (? for the reception of retracted buccal plates) are cut in the peristomial "escarpment". The actual aperture is very slightly elliptical.

,, 2.—Interior of peristome of *Echinocorys vulgaris*. × 5. Except in area 5 the floor of the test increases in thickness towards the peristome. In the four lateral interambulacra single, crescentic hollows excavate the "escarpment". The horns of the crescents in areas 2 and 3 are often nodular, being the "auricles" noted by Klinghardt.

,, 3.—Plan of interior of peristome in *Echinocardium cordatum*. In area 1 there is a small knob which rises partly from the neighbouring ambulacral plates. In area 4 a long, twisted mesentery-support rises from foundations exactly similar to those in area 1. The edge of the labrum is slightly reverted. There is no special modification in areas 2 and 3.



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INTERIOR OF PERISTOME IN *CONULOPSIS*, *ECHINOCORYS* AND

III.—The Suffolk Boxstones and their probable Age.

By Alfred Bell.

(PLATES III AND IV.)

THE detrital matter underlying the Suffolk and N.W. Essex Crags forms an incongruous mass of disrupted local rocks and fossils, supplemented by a few transported boulders of igneous and sedimentary rocks of different ages and mostly small. To these have to be added organic remains of many classes in various conditions of preservation.

The bulk of this miscellaneous assortment consists of clays and sands metamorphosed by phosphatization and other agencies, whose fossils indicate two or more distinct horizons; to place these in their proper geological positions it is requisite to see what relations they bear to those of the deposits, or strata, above and below, and to consider the causes that brought them into their present position.

The area occupied by this detritus is exceedingly limited, not more than sixty square miles in extent, the remains of a much larger surface, now lost or destroyed by marine action wearing away the coastline. Red Crag, with flints and phosphates, occurs a few miles inland as far as Sudbury and Monks Eleigh.

The fossils belong to two series, the older one rich in fishes and crustaceans, usually embedded in a highly phosphatized clay, the so-called "Coprolites". Amongst the fishes, the genera *Cymbium* and *Halecopsis*, with the bodies hardly compressed or altered in shape, are very common; the pavement-toothed *Phyllodus* and *Pycnodus* were frequently obtained when the pits were being worked. The crustacea have yielded eighteen or twenty species, including one *Nephrops Reedii*, Carter, which has not been recognized elsewhere in the London district. These indicate a zone corresponding generally to that of the London Clay of Sheppey in Kent. Both fishes and crustaceans are often in fine preservation, unlike the shells, which seem to have been absorbed or converted into phosphate pseudomorphs, and are not pyritized as they are in the Sheppey area.

Casts of a few of the aragonite mollusca are preserved as a sandy or clayey matrix, but slightly phosphatized, the shelly material having entirely disappeared. It is difficult in these cases to determine to which horizon they belong, as the genera *Cytherea*, *Pectunculus*, etc., are common to both Eocene and Oligocene, the more so as several species, including *Cancellaria* (*Bonellitia*) *evulsa*, a few Volutes, and *Pleurotoma*, *Rimella* and *Hippochrenes*, pass upwards. Professor Prestwich,[1] moreover, says: "The Argile de Boom" (to which I shall presently refer) "attains around Antwerp a thickness of 200 feet, resembling very closely, in its general composition and the facies of its fauna, the London Clay, to which it was originally referred."[1]

The fauna of these older Eocene clays in England and that of the next group to be considered have very little in common, the teleostean fishes and others just mentioned having passed away.

[1] *Geology*, vol. ii, p. 382, 1888.

After eliminating the Eocene faunas referred to, there remains a miscellaneous series of both marine and terrestrial organisms, the former being mostly contained in the boxstones and sandstones, of which they form a part (see GEOL. MAG., September, 1917, p. 408).

Professor Boswell, F.G.S., has carefully examined and described the petrology of the boxstones, and suggests that some of them may have been formed by concretionary segregation of iron oxides, calcium phosphate and carbonate around organic nuclei.[1] As a rule they are irregular in shape, often water-worn, sometimes nearly spherical, and of many degrees of hardness, according to the amount of iron in their composition; the sand at times being apparently full of small tubes (? annelids), loosely cemented, and light in weight and colour. The excessively hard masses are usually devoid of organic remains of any kind. It is impossible to separate these indurated boxstones, spherical or otherwise, from the tabular sandstones and loose shells found in the body of the Crag, presently to be referred to, as the same species of shells occur also in them. These amorphous lumps can hardly be termed nodules in the sense usually understood. In these as in Cromarty, like the Ichthyolite beds of the Old Red Sandstones, in the White Lias, in the Pennystone nodules of the Coal-measures with their exquisitely preserved Crustaceans and other invertebrata, or those of Coalbrookdale enclosing delicate fern fronds and pinnules, the nodules follow the lines of that of the organisms enclosed. The cement stones of the Essex London Clay at Harwich containing Chelonians may also be regarded as larger examples of the same kind.

On the other hand, the fossils of the boxstones often occur at an irregular angle, according to the way in which the sandstone may have broken up. Several individuals are frequently present in the same block.

The Mekran nodules described by Mr. R. B. Newton,[2] fairly represent the usual method of inhumation in the best-preserved boxstones, so that the same words must apply to both. "The condition of the fossils is nearly always that of a natural cast exhibiting internal structure, whilst external features are often preserved in the concavity of the shell."

The exterior of these Mekran nodules, "many as round as a ball with perfectly even surfaces," has but a superficial analogy to that of the boxstones in general.

Dr. J. J. H. (now Sir Jethro) Teall, F.R.S., in his presidential address to the Geologists' Association[3] dealing with "The Natural History of Phosphatic Deposits", describes the boxstones (p. 383) as "nodules of brown phosphatic sandstone which usually contain hollow moulds of *Pectunculus* or other (calcareous) shells", and quotes Dr. H. Credner, who in treating of the phosphate nodules of the Middle Oligocenes of Leipzig where similar nodules occur in place, says, "the phosphate, mainly phosphate of lime, has been concentrated

[1] GEOL. MAG., Dec. VI, Vol. ii, p. 250, 1915.

[2] R. B. Newton, F.G.S., "Marine Fossils in Limestone Nodules found on the Mekran (Baluchistan) Beach": GEOL. MAG., Dec. V, Vol. ii, 1905.

[3] Proc. Geol. Assoc., vol. xvi, p. 369, 1899–1900.

round calcareous shells and fish remains, but the shells have entirely disappeared, and the fish are represented only by the more insoluble portions of their skeleton." "Carbonic acid and ammonia are formed in connection with the decomposition of animal matter." "Phosphate of lime is soluble in water, charged with carbonic acid, and still more so in water containing ammonium carbonate. A solution of ammonium phosphate is thus formed at the expense of the fish bones, and one of calcium carbonate at the expense of the shells. The shells and the fish embedded in the porous sand thus become surrounded by water highly charged with calcium carbonate, or ammonium phosphate. Where these solutions react there is a precipitation of calcium phosphate and some carbonate; in this way the loose sand becomes consolidated into a hard nodule." Dr. W. B. Clarke [1] was the first to give any detailed account of the detritus bed. He especially refers to the boxstones as "arenaceous clay nodules that have been rounded by attrition into forms, more or less spherical, upon breaking which a shell, frequently a bivalve, is found in the interior. In some cases the shell itself is preserved, in others nothing but the cast remains". He seems to have anticipated Dr. Credner by saying, "It is not unlikely that the presence of the shell and its molluscous inhabitant, involving certain chemical changes within the mass of clay, may have given rise to the consolidation of the surrounding mass."

Many phosphatic concretions were dredged by the *Challenger* off the Cape of Good Hope and elsewhere, where sharks' teeth abounded, as many as 1,500 examples of these being taken in one haul of the dredge. Sharks' teeth abound in the loose sand of the older Red Crag; nearly all the species are recorded from the Continental Oligocene, while a few survive to the present time.

In working out the relations of the boxstone fauna to that of other formations I have utilized the lists given by Dr. Harder,[2] Dr. Ravn,[3] M. Vanden Broeck,[4] Dr. Nørregaard,[5] and by Mr. R. B. Newton, F.G.S.[6] In making these comparisons I have left out the loose derivative shells found in the Red Crags, but these are all referred to by one or other Continental writers as being of Oligocene age, and do not affect the conclusions at which I have arrived.

Harder quotes 93 species from the Oligocene zones; 21 of these are boxstone species, chiefly Middle Oligocene (23 per cent approx.).

Ravn 91 species, Middle and Upper Oligocene, of which we have 36–40 (44 per cent).

Vanden Broeck 64 species, Middle Oligocene; Argile de Boom (Upper Rupélien) 22–24 (38 per cent); Lower Rupélien (Berg) 62 species, of these I have only found 10 in the boxstones.

[1] "A few remarks upon the Crag of Suffolk": Ann. Mag. Nat. Hist. (2), vol. viii, p. 205.
[2] Danmarks geologiske Undersøgelse, vol. ii, 1913.
[3] K. Danske Vid. Selsk. Skrift (7), vol. iii, p. 217, 1907.
[4] Bull. Soc. Belge de Géologie, vol. vii, p. 78, 1893.
[5] Dansk. Geol. Forening., vol. v, No. 1, 1916.
[6] Journal of Conchology, vol. xv, 1916–17.

Dr. Nørregaard's list of 64 species, as noted further on, yields 16, or 25 per cent, boxstone forms. Mr. Newton's list of 77 species, 10 or 11, or about 13 per cent.

Ravn's list, when closely examined, gives 51 Middle Oligocene species, including 15 boxstone forms or about 30 per cent, as compared with Vanden Broeck's 38 per cent.

These analyses show that the "boxstone" sands are nearer to the Oligocene Argile de Boom than to any of the others; they may be classed, I suggest, as Upper Rupélien.

De Koninck, in his classic memoir on the fossil shells of Basele, Boom, etc., has figured or described many of the shells since found in the boxstones; the above view is strengthened by the presence, both here and in Belgium, of similar types of vertebrates, many Elasmobranch fishes and Crustaceans, various species of fossil woods, and vegetable debris.[1]

Dr. Clarke noticed the abundance of long thin rolled plaquettes of waterworn bones, which caused Sir E. Ray Lankester to call the deposit in which they occur "the Suffolk bone-bed". They are seldom, if ever, coated with the sandstone matrix, and it is very probable that they did not become mineralized till a later period, as the bony fragments enclosed in the nodules do not show any signs of such action.

Phosphatization is not confined to age or place, as Sir Jethro Teall[2] has pointed out. Professor Herdman[3] says also of certain oysters: "The shells were worn, many were brown in colour and polished, indicating a partial conversion into a phosphatic condition."

The presence of fossiliferous boulders in the north-west continental area bordering the North Sea is well known. Herr Nørregaard[4] states he has collected these *blocs* from a *tuilerie* near Esbjerg, and although he classes them as Middle Miocene notes that "their fauna differs considerably, in certain respects, from that of the Danish Miocene" (op. cit., p. 46). His list of fossils from these boulders runs into sixty-four species. Sixteen of these, including *Cardium cingulatum*, *Turritella Geinitzi*, *Aporrhais speciosa*, and *Pleurotoma Steinvorthi*, are included in our boxstone fauna.

Mr. Harmer informs me that Mr. van Waterschoot van der Gracht, the Director of the Geological Survey of Holland, told him that blocks of fossiliferous limestone, believed to be of Oligocene age, were not infrequently dredged by the North Sea fishermen.

The "fossiliferous limestone block from the North Sea"[5], described by Mr. R. B. Newton, F.G.S., seems to have had a similar history. It "has not suffered a sea change", nor does it show any signs of abrasion or water-action. The stone is, I suggest, older than Mr. Newton makes it, and has been, I think, but recently cleared of the enveloping clay. I am sorry to disagree with his interpretation

[1] Mem. Acad. Roy. Bruxelles, vol. xi, 1837.
[2] Proc. Geol. Assoc., vol. xvi, p. 385.
[3] *Report on Ceylonese Pearl Fisheries*, Roy. Soc., 1903, p. 348.
[4] "Mellem Miocæne Blookke fra Esbjerg": Dansk. Geol. Foren., vol. v, No. 1, 1916.
[5] Q.J.G.S., vol. lxxii, 1917.

of certain forms, but in place of *Ranella gigantea*, *Aporrhais pespelicani*, and *Yoldia oblongoides*, for example, I am inclined to read *Triton flandricum*, *Aporrhais speciosus*, and *Yoldia glaberrima*, all well-known Oligocene or Miocene species. The *Natica* figured as *N. Alderi* is not the recent form found in British seas; it may possibly be a variety of *N. Nystii*, like the one figured by Harder (op. cit., pl. v, fig. 27).

Another question arises in connexion with the "boxstones", i.e. how did the terrestrial mammalia and extra-local rocks become associated with them, the vertebrates being of Miocene and Pliocene ages, a connecting link appearing in the Mastodon tooth, described by Sir E. Ray Lankester as having the valleys or hollows between the cusps filled with the boxstone matrix.

The latter writer described the detritus bed as a great beach or littoral accumulation formed immediately before the Coralline Crag and derived from many sources. I venture to suggest a different solution, viz. that the older phosphatized clays were originally deposited as the upper portion of the London Clay, as testified by its fossils, the boxstone sands being afterwards laid down upon this, both clays and sands having been but little removed from their original situation.

The sands were probably deposited in the coralline zone at a moderate depth, the presence of so many double bivalves with valves closed, and the almost total absence of any of the littoral or shore-haunting molluscs, being a conspicuous feature. In due time this edge of the Anglo-Belgian basin became raised above the sea-level, and remained during that period of elevation as an upraised plain on whose surface the animal remains referred to were accumulated in local fluviatile deposits from time to time.

Both clays and sands seem to have been desiccated and disintegrated before the time of the Coralline Crag, but not disturbed, as we find it in position beneath the borders of this deposit at Sutton and Boyton. Beyond this it disappears, no traces of it having been found by Mr. F. W. Harmer when boring into the Crag outside these places.

The detritus did not pass up into the body of the Coralline Crag, but in the succeeding zones, the Oakleyan and Newbournian stages, the Red Clay is full of the broken-up debris,[1] and flints became abundant either as isolated blocks of large size and unabraded, with the cortex beautifully preserved or as waterworn pieces of smaller size.

Under the submarine currents of the Coralline Crag sea the floor was but little disturbed, but at the close of its earliest portion, the Gedgravian of Harmer, a change in the fauna commenced, and the Boytonian period ushered in sundry tectonic changes, several species of northern or boreal mollusca, such as the *Belas*, making their appearance for the first time in East Anglia. This zone or period passed away, and with it a part of the older southern fauna, to be replaced by a more northern one. The flints just mentioned were due, according to Sir C. Lyell, to ice-action. Many of the smaller

[1] See Bell, "Sub-Crag Detritus": Proc. Prehistoric Soc. East Anglia, 1915, vol. ii, not vol. xi as on p. 408 (*ante*).

pieces occur in patches, on strings in slight depression of the soil beneath, as if an ice-floe, loaded with these stones, had grounded, leaving its burden intact. One such flint patch is present between the Coralline and Red Crag at Pettistree Hall, Sutton, on the Coralline Crag Hill of Prestwich,[1] where I saw it in situ.

In the Newbournian period of the Red Crag, stormy seas seem to have been the normal feature, churning up the disintegrated sea-floor with its contents so as to make the fragments an integral part of the deposit it was then building.

The fossils selected in illustration of this paper have been chosen as specimens of the various ways in which they occur, or as being unfigured species. The nomenclature I have used in this and the earlier paper will not perhaps commend itself to some scientific experts, but may be the better understood by ordinary workers in the Crag as being the language they are more familiar with, and will enable them to refer to earlier writers with greater facility. These continual changes in nomenclature are very bewildering to students in general.

A further revision of material, lately come to hand, enables me to add a few species to those already quoted in No. 639 of the Geological Magazine, September, 1917.

? *Liomesus Feldhausii* (Beyrich), Zeitsch. deutsch. geol. Ges., vol. viii, p. 243, pl. i, fig. 9, 1856. Mus. Pract. Geol. London.

[Except that the boxstone shell is larger than the type there seems to be no difference, either in form or sculpture.]

Pseudocassis Harmeri, n.sp. (see p. 413 *ante* for reference). Harmer Coll.

Solarium Hörnesii, Michelotti, Etud. Mioc. inf. Ital., p. 92, pl. x, figs. 11–12, 1861. Mus. Ipswich.

[Two examples, both showing the underside, may be referred to this species. Moulds of the wall of the umbilical opening may be easily mistaken for the upper whorls of a small *Cancellaria*.]

Cardium fragile, Brocchi, Conch. foss. subap., vol. ii, p. 505, pl. xiii, fig. 4, 1814. Mus. Pract. Geol. London.

Mactra ovalis, J. Sowerby, Min. Conch., vol. ii, p. 136, pl. clx, figs. 2–5. Mus. Pract Geol. London.

[The two last-named occur with *Pecten Rupeliensis*, *Pectunculus*, and a number of others—mostly imperfectly exposed bivalves—in an irregular plaque of sandstone, see *ante*, p. 408.]

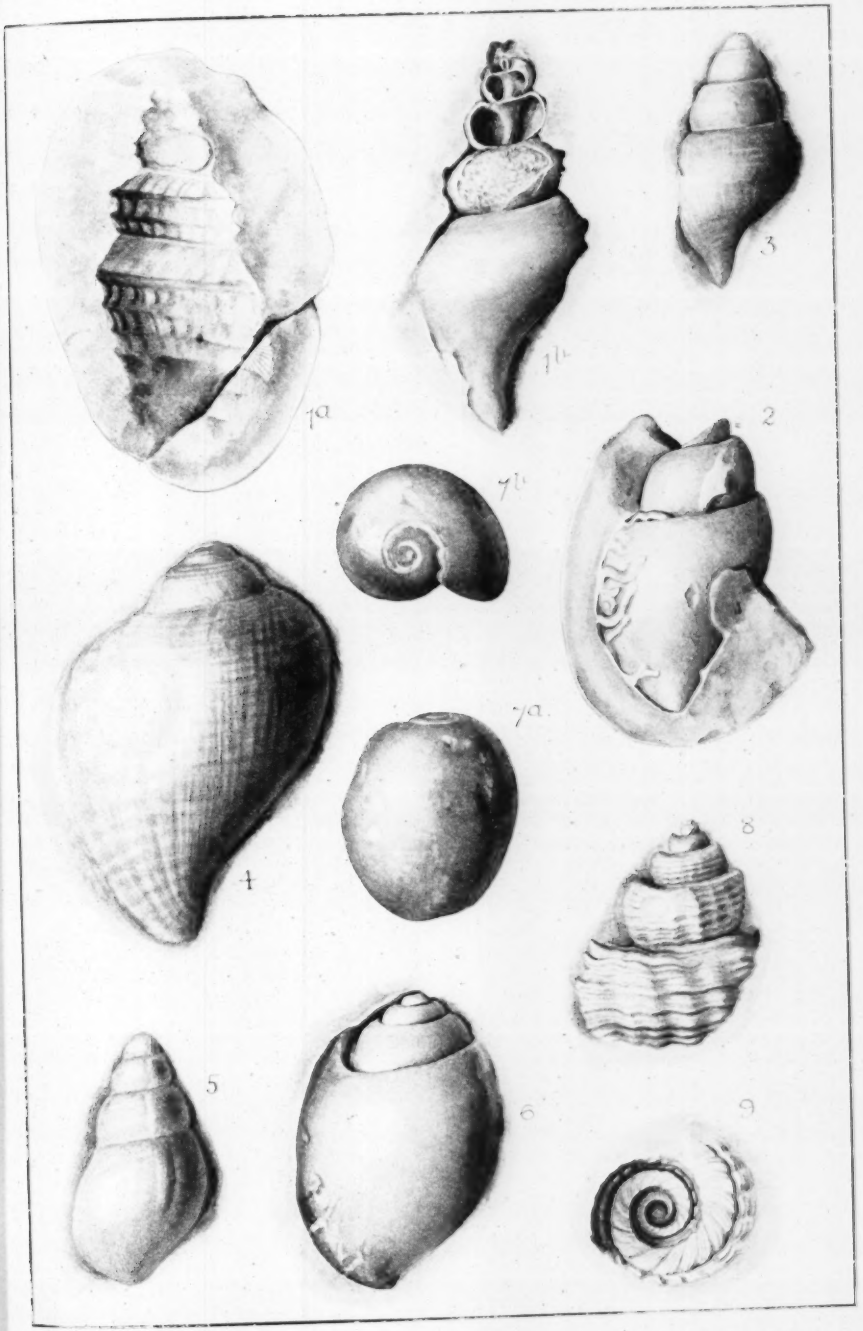
EXPLANATION OF PLATES III AND IV.

Plate III.

Fig.

1. *Fasciolaria erratica* (De Koninck), p. 411. 1*a* shows details of sculpture, 1*b* the internal mould. Mus. Ipswich.
2. *Sipho Ravni*, n.sp., p. 411. Mus. Ipswich.
3. ? *Liomesus Feldhausii* (Beyrich). Mus. Pract. Geol. London.
4. *Ficula acclinis* (S. V. Wood), p. 412. Mus. Ipswich.
5. *Cominella conica*, n.sp., p. 412. Mus. Ipswich.
6. *Semicassis saburon* (Bruguière), p. 412. British Mus.
7. *Pseudocassis Harmeri*, n.sp., p. 413. Pseudomorph in a phosphatized matrix. Harmer Coll.
8. *Trigonostoma* cf. *ampullacea* (Brocchi). Mus. York.
9. *Solarium Hörnesii*, Michelotti. Mus. Ipswich.

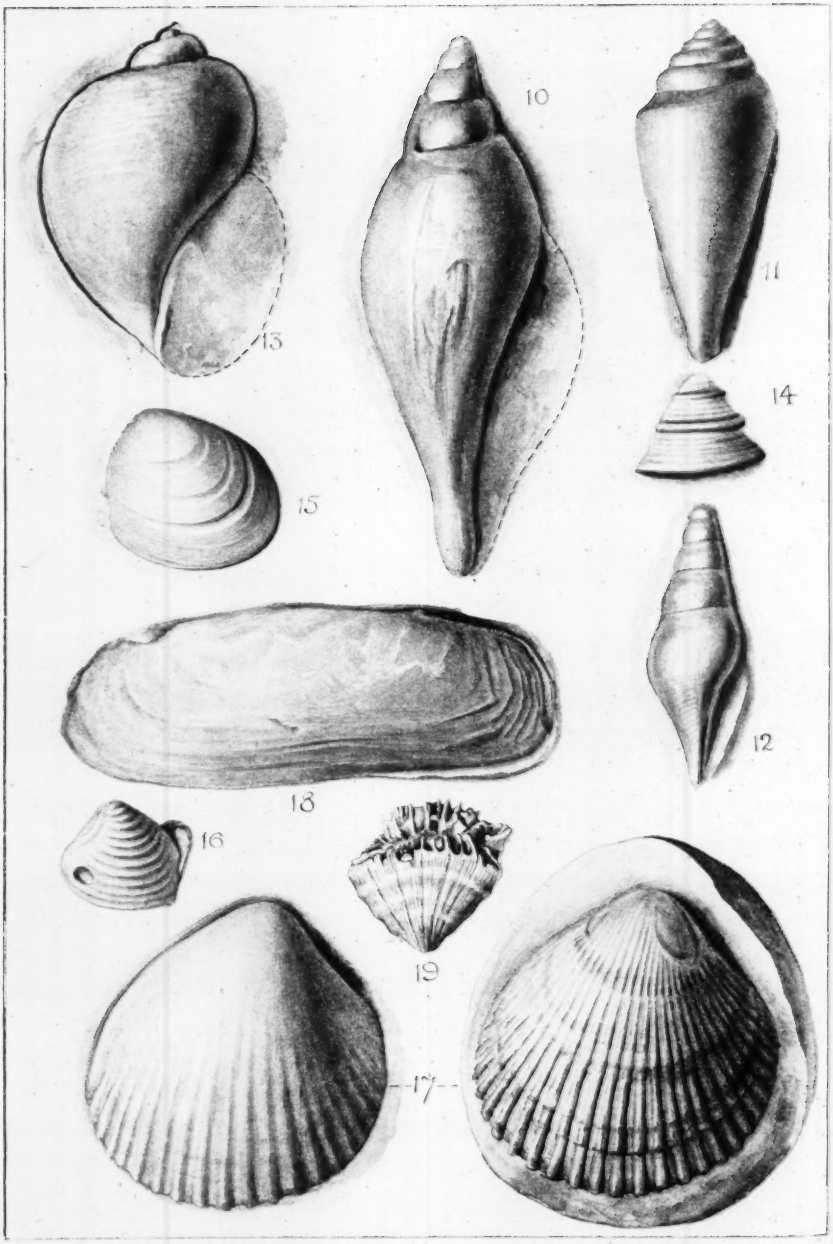
[1] Q.J.G.S., vol. xxvii, 1870.



Bale, imp.

S. H. Woodward del.

CASTS OF SHELLS FROM THE SUFFOLK "BOX STONES."



G. M. Woodward del. Hale, [illegible]

CASTS OF SHELLS FROM THE SUFFOLK "BOX STONES."

PLATE IV.

FIG.
10. *Voluta* (*Pyrgomitra*) *fusus* (Philippi), p. 410. Mus. Ipswich.
11. *Conus antediluvianus*, var., Grateloup, p. 410. Mus. Pract. Geol. London.
12. *Pleurotoma Steinvorthi*, Semper, p. 410. Mus. York.
13. *Natica ferruginea*, var. (in Sacco), p. 414. Mus. Ipswich.
14. *Calliostoma Xavieri* (Costa MS.), p. 415. Mus. Ipswich.
15. *Nucula placentina*, Lamarck. Mus. Ipswich.
16. *Astarte Kickxii*, Nyst., p. 417. Mus. Pract. Geol. London.
17. *Cardium Woolnoughi*, n.sp. 17*a* shows the sculpture as seen in the intaglio or hollow mould. 17*b*, inner mould of organism with the shell removed by decalcification. Mus. Pract. Geol. London.
18. *Cyrtodaria vagina* (S. V. Wood). Mus. Pract. Geol. London.
19. *Flabellum cuneatum* (Goldfuss). Bell Coll.

IV.—THE NORITE OF THE SIERRA LEONE.

By Professor S. J. SHAND, D.Sc., F.G.S., University of Stellenbosch, South Africa.

THE Sierra Leone, from which the Colony of Sierra Leone takes its name, is a range of palm-covered hills running parallel to the coast (N.N.W.–S.S.E.). It is truncated on the north by the wide mouth of the Roquelle (Rokell) River, which forms the magnificent harbour of Freetown. Towards the south the range terminates at Yawry Bay. The length of the Sierra is therefore about 25 miles and its width, from Kassa Town to Kissy, about 8 miles. On the east side the range descends steeply to the Kwaia plain, from which it is separated by Waterloo Creek. The detachment of the hills from the interior lowland is sufficiently complete to entitle one to speak of the Sierra Leone Peninsula. Freetown is built on the north end of the peninsula, overlooking the harbour, and it straggles up from sea-level to a height of some 800 feet on Wilberforce Hill. The greater part of the peninsula is covered with thick tropical vegetation right down to sea-level; and an additional obstacle to geological study is created by the heavy covering of laterite which screens the rocks from observation. In places this laterite mantle is 30 feet thick. But along the northern shore of the peninsula, from Cape Sierra Leone to the mouth of Waterloo Creek, there are nearly continuous exposures of norite, and further useful exposures have been made during the construction of the Hill Railway and along certain of the roads on the hillside. These outcrops make it clear that the whole of the north end of the Sierra is formed of norite, and it would not be surprising to learn that the entire Sierra has the same composition.

The norite or gabbro of Freetown was described by G. Gürich in 1887,[1] and I have not been able to trace any subsequent reference to it. Rocks from the interior of the colony were examined by G. F. Scott Elliot and Miss C. A. Raisin in 1893,[2] and as far as I am aware no further contribution to the geology or petrology of the country has been made since that date. I spent a few days in Freetown recently, and took advantage of the opportunity to examine the rocks and collect a few specimens. I can add little to the account of the

[1] Zeit. der Deutschen Geologischen Gesellschaft, vol. xxxix, p. 108.
[2] Colonial Reports, Misc., No. 3 (Sierra Leone), p. 61.

norite given by Gürich, but where the whole store of observations is so meagre any addition to it ought to be useful. It is desirable in any case that records relating to British colonies should be accessible in the English language.

The rock, as exposed about Freetown and on Wilberforce Hill, shows the following textural facies.

1. A coarse-grained variety, sometimes forming definite pegmatite veins, composed mainly of felspar plates in sub-parallel arrangement. Some of the crystals are nearly an inch in diameter, and their colour is iron-grey. The coarser the grain of the rock, the smaller the proportion of heavy minerals, which may sink to 5 per cent or less.

2. A medium-grained variety which may be called the average rock, in which the felspar crystals have diameters of 2 to 4 mm. The arrangement of the crystals is still sub-parallel. Olivine grains are prominent, and the heavy (or mafic) minerals constitute about 25 per cent of the volume of the rock.

3. A fine-grained variety in which the crystals are equidimensional and have an average diameter of less than 0·5 mm. The texture is similar to that of an aplite, or what is sometimes called a "trap-granulite". Heavy minerals make up some 60 per cent of the whole. I believe this facies of the rock to bear the same relation to the last that an aplite bears to a granite.

The following minerals are present: plagioclase, olivine, hypersthene, diallage, titanomagnetite.

The *plagioclase* is entirely fresh and glassy, and invariably dark-grey in colour. In general it forms pinacoidal tables with Carlsbad and albite twinning, but in the aplitic rock it appears in anhedral grains. The extinction angles show it to be an acid labradorite, approaching $Ab_3\ An_1$. No zonal structure could be detected.

Olivine is an important constituent of the average rock, but is entirely absent from the aplitic facies. It is perfectly fresh, or shows only incipient hydration along cracks. The crystals are moulded upon the felspars, and are sometimes mere skeletons embracing numerous felspar laths. Gürich has illustrated this feature in his paper. Olivine is commonly intergrown with diallage and may be enclosed by hypersthene. Some varieties of the rock contain little but felspar and olivine.

Diallage of a smoky-brown colour is the common pyroxene in the coarser varieties of the rock. It is charged with opaque ore-inclusions which lie along planes of parting. It forms skeleton-crystals surrounding felspars, and rounded grains of diallage are often completely enclosed in hypersthene.

Hypersthene is the only ferromagnesian mineral present in the aplitic facies of the rock, but in the average rock it is associated with, and generally subordinate to, diallage. In the former case the hypersthene grains are equidimensional, and they form an even-grained aggregate with anhedral felspar grains of the same size. Even here, however, the hypersthene has demonstrably been moulded on the felspar. In the coarser varieties of the norite the hypersthene occurs in anhedral plates which enclose all the other minerals of the rock. The pleochroism is strong, indicating a high iron-content.

Magnetite (titanomagnetite) is present in irregular, often rounded grains, but some crystals show isometric sections. A highly refracting border (leucoxene?) surrounds some of the grains, indicating the presence of titanium. Scott Elliot noted the occurrence "in the hills behind Sierra Leone" of a titaniferous iron-ore yielding 52 per cent of metallic iron and 14 per cent of Ti O_2. Gürich, too, saw in a private collection of minerals in Freetown lumps of magnetite as large as the fist. I venture to conclude that this ore-body occurs as a segregation within the norite; indeed, the recognition of the petrographic character of the rock would lead one to anticipate the existence of such segregations. These indications ought to be followed up, as they might lead to the discovery of important ore-deposits. The matter is one for the attention of the Imperial Mineral Resources Bureau.

Estimates of the percentage composition of these rocks yielded the following results in the case of (A), a specimen of what I have called the average rock, and (B) the aplitic facies:—

	A.		B.	
	Vol. %.	Weight %.	Vol. %.	Weight %.
Plagioclase . .	74	69	41	35
Olivine . .	14	16	0	0
Diallage }	9	10	{ 0	0
Hypersthene }			{55	59
Magnetite . .	2·3	4	4	6

The order in which the minerals crystallized is as follows: labradorite, olivine, diallage, hypersthene; magnetite uncertain. In brief, the fine-grained rock is a melanocratic norite (m_6 – micronorite), while the coarser varieties are leucocratic olivine-norites (l_6 – to l_9 – subnorite). I invite attention here to a change which ought to be made in the subdivision of the gabbroitic rocks; namely, that in deciding whether a rock is to be attached to gabbro or to norite *the olivine should be reckoned along with the rhombic pyroxenes*, since the latter minerals arise by the addition of silica to olivine. Thus all troctolites and "olivine-gabbros" (including those above described) in which the sum of olivine plus rhombic pyroxenes exceeds that of the monoclinic pyroxenes should be regarded as norite (subnorite), not as gabbro.

NOTICES OF MEMOIRS.

On the Geological Structure of the Forest of Dean.[1] By T. Franklin Sibly, D.Sc., F.G.S., Professor of Geology in the University College of South Wales and Monmouthshire, Cardiff. (A paper read before the Forest of Dean Branch of the National Association of Colliery Managers on October 25, 1917.)

In 1894 Dr. R. Kidston correlated the Coal Measures of the Forest of Dean with the true Upper Coal Measures.[2] In 1910 Dr. T. T. Groom, reasoning from this correlation, pointed out that "unless the

[1] Reprinted (by permission), with some emendations by the author, from the *Colliery Guardian*, vol. cxiv, No. 2966, November 2, 1917, pp. 839–40.

[2] Proc. Roy. Phys. Soc. Edin., vol. xii, p. 222, 1894.

measures that have not been detected [the true Lower and Middle Coal Measures] are exceedingly thin, or are represented by the upper part of the Millstone Grit, there must be an unconformity at the base of the Coal Measures".[1]

The late Dr. A. Vaughan had proved the Lower Carboniferous age of the lowest beds of the Millstone Grit near Mitcheldean.[2] In 1912 Dr. E. A. Newell Arber, whose detailed study of the fossil plants in the local Coal Measures confirmed Dr. Kidston's correlation, wrote as follows: "Reviewing the present evidence I am inclined to think that it will eventually prove that an unconformity exists a short distance below the Lower Trenchard Coal perhaps a little above the Sandstone vein of Iron Ore. . . . True Millstone Grits, Lower, Middle, and Transition Coal Measures appear to be absent in the Forest of Dean, so that the unconformity in question is of considerable importance."[3]

The present author's independent investigations led him in 1912 to the conclusion that an unconformity at the base of the Coal Measures is an important structural feature in the Forest of Dean. In a short paper on the Carboniferous succession[4] he described the Lower Carboniferous sequence near Mitcheldean, proposed the name Drybrook Sandstone for the "Millstone Grit" of the district, and demonstrated the reality of the intra-Carboniferous unconformity by describing the persistent overstep of the Coal Measures across the Drybrook Sandstone and Carboniferous Limestone, as well as by other evidence.

The author has been assisted in his later researches in the district by a grant from the Government Grant Committee of the Royal Society. He is permitted by the Director of the Geological Survey of Great Britain to make use of information gained in the course of his present investigation, as an officer of the Geological Survey, of iron-ores in the Forest of Dean.

It is well established on palæontological evidence that the Carboniferous Limestone of the Forest of Dean represents, approximately, the lower half only of the same formation as seen in the Avon Gorge at Bristol. The zones of the Carboniferous Limestone Series in the Avon Gorge, recognized by the late Dr. Vaughan, are denoted, in ascending sequence, by the symbols K, Z, C, S, D. The highest member of the Carboniferous Limestone on the north-eastern borders of the Forest of Dean, the Whitehead Limestone, represents the topmost part of C (*Syringothyris* zone) and possibly the lowest part of S (*Seminula* zone). The Whitehead Limestone, which rarely exceeds 30 feet in thickness, gives place on the south-western border of the Forest to a series of dolomite-mudstones, black and grey crystalline dolomites, and clays with dolomite nodules, of much greater thickness; but this series does not encroach much on the *Seminula* zone.

[1] *Geology in the Field*, Jubilee Volume of the Geologists' Association, 1910, p. 731.

[2] Q.J.G.S., vol. lxi, p. 252, 1905.

[3] Phil. Trans. Roy. Soc., vol. ccii, B, pp. 270, 277, 1912.

[4] GEOL. MAG., N.S., Dec. V, Vol. IX, pp. 417–22, 1912.

The upper portion of the Carboniferous Limestone of areas to the south is represented in the so-called Millstone Grit of the Forest of Dean. This Millstone Grit, which succeeds the Carboniferous Limestone quite conformably, is mainly, if not entirely, a formation of Lower Carboniferous age. The name Drybrook Sandstone was applied to it in 1912.

Thick bands of limestone and dolomite appear in the Drybrook Sandstone on the south-western margin of the coal-field. Near Milkwall oolitic limestones in the lower part of the formation have yielded *Seminula ficoides*, *Cyrtina carbonaria*, and other fossils of the main *Seminula* zone (S_2). *Cyrtina carbonaria* has also been observed in corresponding beds of dolomite in the Parkhill adit (Fryer's Level). The lower portion of the Drybrook Sandstone may, therefore, be correlated definitely with the main *Seminula* zone of the Carboniferous Limestone. Unquestionably, the Drybrook Sandstone passes laterally into limestones as we proceed from the north-eastern margin of the Forest of Dean southwards to Chepstow and Bristol.

Concurrently with the development of limestones the arenaceous beds, which compose the bulk of the Drybrook Sandstone even on the south-western margin of the coal-field, become finer in grain when followed south-westwards. For example, seams of quartz-conglomerate are conspicuous in the Drybrook Sandstone of the Mitcheldean district, but these have dwindled to insignificance in the neighbourhood of Bream. Bands of shale and fine-grained sandstone, containing shreds of coal, are found in the upper part of the Drybrook Sandstone in the Parkhill adit.

Owing to overstep by the unconformable Coal Measures the Drybrook Sandstone is wholly concealed both on the south-east between Lydney Park and Staple Edge Wood, where the Carboniferous Limestone also is concealed, and on the north between Drybrook and Lydbrook Valley. From the same cause the apparent thickness of the Drybrook Sandstone varies greatly, and in no regular manner, along its outcrop. The thickness is at least 650 feet in the Soudley Valley between the Shakemantle Pit and Staple Edge Halt, where the upper beds are well exposed on the railway.

The Coal Measures of the Forest of Dean lie unconformably, and sometimes with great discordance of dip, upon an eroded floor formed by the Drybrook Sandstone, the Carboniferous Limestone, and on the south-eastern margin of the coal-field, the Old Red Sandstone.

This important unconformity is due to an intra-Carboniferous episode of crust-movement, folding, and denudation which followed the deposition of the Drybrook Sandstone, but preceded the formation of the existing Coal Measures of the Forest. The latter were deposited on the denuded edges of the older strata. An altogether later movement involved the Coal Measures, gave them their present basin-like arrangement, and served also to accentuate the folding previously imposed upon the older rocks.

The intra-Carboniferous disturbance responsible for the unconformity necessarily involved the Silurian and the Old Red Sandstone, together with the Lower Carboniferous strata. It produced the

main uplift of the May Hill anticline lying immediately east of the Forest of Dean. North-and-south folding predominated, but was accompanied by some east-and-west folding. The result was a basin, markedly unsymmetrical in structure, on the site of the present coal-field. Along what is now the eastern edge of the coal-field the Lower Carboniferous strata were involved in the western limb of the May Hill anticline, and acquired a steep dip westwards, the larger part of the very steep dip that they possess to-day. Westwards across the site of the present coal-field, away from the May Hill axis, the intensity of folding diminished very rapidly, and on the western side of the basin the inward dip of the strata was very slight. Consequently, the beds of the Coal Measures are nearly, but not exactly, accordant with the underlying strata on the western side of the present coal-basin, but markedly discordant with them on the eastern side. But, slight though the discordance may be on the western side, the behaviour of the outcrops supplies convincing evidence of unconformity all around the coal-field. The base of the Coal Measures pays no regard to the strike of the Lower Carboniferous beds, but everywhere passes to and fro, slowly or rapidly, across their outcrops.

Two interesting and significant features are (1) the development of conglomerates at the base of the Coal Measures, and (2) the concealment of the Trenchard Coal and the measures beneath it by the overlap of the overlying measures, on the south-eastern border of the coal-field. These may be described in connexion with the unconformable overstep of the Coal Measures.

The lowest beds of the Coal Measures, those underlying the Trenchard Coal (Upper Trenchard Coal in some parts of the coal-field), were termed Trenchard Measures by the late H. D. Hoskold.[1] The Trenchard Measures, although variable in character, usually consist largely of yellow grits, in part fine-grained, compact, and well-bedded, in part coarse-grained, friable, and imperfectly stratified. The intercalated clays are sometimes mottled in purple and yellow. A characteristic feature of these grits, particularly in the coarse-grained and conglomeratic varieties, is the abundance of an indurated, white or yellow clay cementing the grains. On the northern and north-eastern borders of the coal-field these grits of the Trenchard Measures often become very coarse-grained and pebbly at their base, and bands packed with quartz pebbles or quartzite pebbles constitute well-defined basal Coal Measure conglomerates.

On the northern edge of the coal-field, between Drybrook and the Lydbrook Valley, the base of the Coal Measures transgresses the older strata rather sharply, the Drybrook Sandstone and the upper beds of the Carboniferous Limestone are concealed, and the grits of the Trenchard Measures rest directly upon Carboniferous Limestone. A quarry 1,100 yards east of Ruardean Church shows masses of coarse, pebbly grit resting upon, and in places "piped" down into, the dolomites of the Carboniferous limestone. The former extension of Coal Measures northwards and westwards across the denuded

[1] "Geological Notice upon the Forest of Dean": Proc. Cotteswold Nat. Field Club, vol. x, pp. 123–77, 1892.

edges of the underlying strata is proved by outliers of Trenchard Measures. In the large outlier of Howle Hill, represented as Millstone Grit on the Geological Survey map (sheets 43 S.W. and 43 S.E., Old Series), Trenchard Measures rest directly upon the Lower Limestone Shales. A smaller outlier on Courtfield Hill, Welsh Bicknor, not shown on the Survey map, rests upon the Lower Limestone Shales and the base of the Main Limestone.

The railway-cutting immediately north of Drybrook Halt gives a fine section of Trenchard Measures resting upon massive sandstones which lie in the lower part of the Drybrook Sandstone. The basal beds of the Coal Measures is here a remarkable pebble-bed with large, well-rounded pebbles of grey quartzite. This pebble-bed has been traced some distance north of Drybrook, and has been recognized in the Howle Hill outlier.

On the eastern edge of the coal-field from Wigpool Common as far south as the Soudley Valley, the Trenchard Measures rest upon Drybrook Sandstone. In the Soudley Valley, the railway-cutting south of Staple Edge Halt exposes the unconformable contact of the two formations. Conglomerates forming the base of the Trenchard Measures, and containing fragments of a fine-grained, white sandstone which can be matched in the Drybrook Sandstone of the same cutting, rest upon the Drybrook Sandstone with discordance of dip. The average dip of the Drybrook Sandstone in the cutting is 50° W.N.W. The conglomerates dip slightly north of west at about 25°.

South of the Soudley Valley, overstep carries the base of the Coal Measures southwards, and then eastwards, across fully 650 feet of Drybrook Sandstone and the whole of the Carboniferous Limestone, in the distance of barely 2 miles to the southern side of the Blackpool Valley. The Lower Carboniferous strata maintain a steep north-westerly dip, rising to 65° in places, as their strike swings gently from S.S.W. to S.W. The Coal Measures maintain a moderate dip a little north of west. The Drybrook Sandstone and the upper beds of the Carboniferous Limestone are transgressed gradually in Staple Edge Wood. The bulk of the Carboniferous Limestone is transgressed very sharply in the Blackpool Valley. On the south side of that valley the base of the Coal Measures continues its rapid overstep eastwards until, just north of Danby Lodge, it crosses the quartz-conglomerates which lie some 400 feet down in the Old Red Sandstone.

In consequence of this sharp overstep the Carboniferous Limestone and the Upper Series of the Old Red Sandstone remain wholly concealed from Danby Lodge to the western side of the Cannop Valley, above Lydney. In and near Stonebury Wood, north of Lydney Park, the quartz-conglomerates of the Old Red and the beds of the Carboniferous Limestone, dipping very steeply westward, reappear from underneath the cover of unconformable Coal Measures. The sharp swing of the Coal Measure base here carries it back rapidly from the Old Red Sandstone on to the Drybrook Sandstone in Old Park Wood.

The unconformable *overstep* of the Coal Measures is attended, on

the south-eastern margin of the coal-field, by conformable *overlap*. The Trenchard Coal and the underlying Trenchard Measures are overlapped by the Pennant Sandstone above them. As a result, the Pennant comes to rest directly and unconformably upon the older, steeply inclined strata, and the Trenchard Measures fail to crop over a considerable part of the distance between Staple Edge Wood and the Cannop Valley. This is abundantly clear at Danby Lodge, where the Pennant Sandstone, containing the Coleford High Delf Coal, transgresses the quartz-conglomerates of the Old Red. It is confirmed by the section in an old quarry on the northern side of the Blackpool Valley, which shows the unconformable junction of Pennant Sandstone and Carboniferous Limestone. The sandstones in this quarry dip gently westwards. They show lenticles of clay and a streak of very coarse grit or quartz-conglomerate at their base, and repose upon the worn, hummocky edges of dolomite-beds which dip north-westwards at about 60°.

To sum up, an unconformity at the base of the Coal Measures is a dominant feature in the geological structure of the Forest of Dean. It is evidenced (1) by the overstep of the Coal Measures across the Drybrook Sandstone, the Carboniferous Limestone, and the Old Red Sandstone, (2) by a great difference between the prevailing dip of the older strata and that of the Coal Measures along the eastern margin of the coal-field, and (3) by visible discordance of dip at exposed junctions of the Coal Measures with Drybrook Sandstone and Carboniferous Limestone respectively. It is attended by (1) the development of basal conglomerates in the Coal Measures, particularly well seen on the northern border of the coal-field, and (2) local overlap of the Trenchard Measures by the Pennant Sandstone, whereby the former are concealed along part of the south-eastern edge of the coal-field.

REVIEWS.

I.—Geological Survey of Great Britain.

Summary of Progress of the Geological Survey of Great Britain for 1916. 8vo; pp. iv + 56 and 3 figures in text. London, 1917. Price 1*s.* 6*d.*

As was only to be expected, the energies of the Geological Survey have been almost entirely diverted into new channels connected with the War. Ordinary field work and detailed mapping are completely suspended, and the remaining staff has devoted itself to the investigation of certain pressing problems connected with the mineral resources of the country. Almost the only exception to this statement is the continuance of the work of examining bore-holes now in progress; this information, if not recorded at once, is necessarily most difficult to recover at a later date. Five volumes of Special Reports have been published dealing with the occurrence of certain minerals of economic value, and a further volume is in preparation on the subject of refractories; these include sandstones, quartzites, ganister, sands, and fireclays (acid refractories), as well as the basic rock dolomite. These are used for furnace linings and

hearths, moulding sands, silica bricks, fire-bricks, and many other purposes. In Scotland the examination of the coal-field has been continued, most of the Highland staff being transferred thither, and several volumes of special district memoirs have been published or are in preparation. The Dalry iron-field has also been investigated in detail as a likely source of further supplies of iron-ore of good quality. The work of the Chemical Department has lain chiefly in the analyses made in connexion with the report on refractories.

The *Summary of Progress* also contains three important appendices on deep borings, one in Yorkshire, 7 miles north-west of Doncaster, the others in Kent and Sussex. The fourth appendix, by Mr. G. W. Lamplugh, F.R.S., contains a summary of the present state of our knowledge of the underground range of the Jurassic and Lower Cretaceous rocks in East Kent, including a good deal of information that has only become available since the publication of the memoir on the subject in 1911. Some of these results were not accessible till after the printing of Mr. Baker's paper on the same subject in the December Number of the Geological Magazine. The general result of Mr. Lamplugh's work is that the Jurassic and Lower Cretaceous rocks together form a great wedge with a northward apex, intervening between the Palæozoic floor and the Gault, and that the northern part of the Wealden anticline is superimposed upon a syncline of the deeper rocks. This interesting result has become much more clearly apparent from the later borings, although it could be demonstrated from the earlier data.

R. H. R.

II.—Geological Survey of Scotland.

The Economic Geology of the Central Coal-field of Scotland. Description of Area II. Mem. Geol. Surv. Scotland. pp. iv + 89, with folding maps and sections. Edinburgh, 1917. Price 4*s.* 6*d.*

THE Scottish branch of the Geological Survey is making rapid progress with the publication of its excellent series of nine memoirs on the coal-fields of Scotland. Those relating to areas V and VIII have already been noticed in the Geological Magazine. The present volume deals with area II, which lies almost wholly within the county of Stirling, and includes the Coal-measures of Banknock, Carron, Falkirk, and Slamannan, and the coals and iron-stones of the limestone coal group of the Plean and Denny districts. The coal-seams are described with the usual amount of detail, and from the figures given it is clear that the majority of them come within the category of thin coals; these, however, will doubtless be profitably worked in the future with improved methods and machinery. The Millstone Grit Series of Cumbernauld, Castlecary, and Bonnybridge includes important beds of fireclay and ganister, which are now of great and increasing importance as refractories. Several analyses show that these fireclays are of very good quality and are likely to be largely developed within a short time. The raised beaches, alluvium, and peat are also briefly described. The peat is likely to be of considerable economic value, and indeed was

already worked before the War for moss-litter; this industry has now ceased.

R. H. R.

III.—Dominion of Canada, Ottawa.

Annual Report on the Mineral Production of Canada during the Calendar Year 1915. By John McLeish. pp. 364. Ottawa: Government Printing Bureau, 1917.

NO doubt the delay in the publication of this report is due to war conditions. It is not, however, so belated as might at first sight appear, since the more important parts saw separate publication at a much earlier date, and a preliminary report was issued as early as February, 1916; moreover, the preface is dated September 21, 1916.

The mineral resources of Canada are very considerable, and are as yet far from being fully developed. The greater portion of the present production is exported for consumption or refining outside the Dominion, while on the other hand considerable quantities of the products of the mines, after refining or partial treatment, or in the shape of manufactured goods ready for consumption, are imported. Nearly half the total output, considered from the point of view of value, comes from the Province of Ontario, thanks largely to the richness of the nickel-cobalt-silver minerals of Cobalt, British Columbia, which ranks second, coming a long way behind. The whole of the copper, nickel, and silver, and much of the gold is exported for treatment. It is interesting to note that of the total amount of mine products exported 72 per cent went to the United States and 25 per cent to the United Kingdom. Much of the world's supply of asbestos is contributed by Canada, and for the dozen years to 1915 the exports of asbestos have averaged over 85 per cent of the total shipments; it may be noted that the mineral in question is chrysotile (fibrous serpentine) and not the asbestos of mineralogists (fibrous amphibole). The report covers the first complete year of war, and shows clearly that already the War was having a marked effect on mining; the iron and steel industry in particular was very active during the year.

The report is well and neatly arranged, so that reference to it is easy, and the salient features are readily grasped.

IV.—Summary Report of the Geological Survey, Department of Mines, for the year 1916. pp. ix+419. Ottawa, 1917.

THIS large and closely printed volume gives striking evidence of the activity of the Canadian Geological Survey. Owing to the War the conditions are necessarily exceptional, and the indoor work of the department has been considerably hampered by the taking over of its permanent quarters to afford a temporary home for the Canadian Parliament after the great fire in February, 1916. The outdoor work has naturally been largely concerned with the examination of districts likely to yield products of special value at the present time. One of the most important of these is tungsten, which has been found in considerable quantities in the Yukon

Territory, as well as in New Brunswick and Nova Scotia. The present high price has naturally stimulated the development of even small deposits of the ores, which include both wolframite and scheelite. In the Lillooet district of British Columbia molybdenite ore has been found in streaks and veins in a mass of very quartzose granite and is now undergoing development. The molybdenite mine of Guyon, Quebec, is also important. Another industry comparatively new to Canada is the mining or quarrying of magnesite, for which there is a large demand in America as a refractory to replace the magnesite formerly imported from Austria and Greece. The magnesite deposits of the Grenville district have already been noticed in this Magazine, and the mineral is also being worked in British Columbia and other districts. The Californian magnesite belt appears to extend into British Columbia.

One of the most interesting sections of the Report is that dealing with investigations for coal, oil, gas, and artesian water in Alberta and Saskatchewan. As is well known, Western Canada possesses great stores of lignitic coal, forming one of the largest continuous coal-fields of the world. This is now undergoing rapid development following on the advance of transport facilities. The oil and gas-field of Alberta has now reached a stage of important productiveness, and the gas is utilized on a very large scale for light, heat, and power in the cities of Calgary, Medicine Hat, and others. The strata from which the gas is derived are of Cretaceous age, and the structure is a broad, low anticline, plunging northwards; the gas-bearing strata occur at two horizons at depths on the average of about 700 and 1,000 feet from the surface. In the Medicine Hat area there are thirty gas-wells, which yield about 88,000,000 cubic feet per day. Borings to still greater depths have yielded a strong flow of saline water.

Besides the economic work, the officers of the Survey have carried out a very large amount of stratigraphical, palæontological, and general geological investigations in all parts of the Dominion, much of which is of great interest, but cannot here be mentioned in detail.

R. H. R.

V.—The Coal-fields and Coal Industry of Eastern Canada: A General Survey and Description. By Francis W. Gray. pp. 67, with 26 plates and 1 map. Ottawa: Government Printing Bureau, 1917.

THIS ably written bulletin contains much of interest both to the geologist and the economist. The Carboniferous area is all within the maritime provinces, and is nearly a parallelogram in shape, the four corners of which are the mouth of Chaleur Bay on the west, Fredericton, New Brunswick, on the south, Arichat, Cape Breton, on the east, and the head of St. George's Bay, Newfoundland, on the north. The Carboniferous rocks occur on both sides of the Cabot Straits, and are possibly continuous under the sea. Unlike the common practice which prevails in the United Kingdom, the United States, and indeed in other parts of Canada, the mineral rights are

in the hands of the Government of the Province. This happy result came about in a rather curious manner. In 1784, when Cape Breton was made a separate province, the Privy Council reserved to the Crown all the coal and other valuable minerals, and had earlier forbidden the mining of coal, so that the unfortunate colonists had the mortification of seeing the coal which fell from the cliffs on to the shore washed out to sea. The Crown did not make a wise use of the Royal prerogative, but leased the mines to the Duke of York, who happened to be deeply in debt at the time. The lease was eventually broken in 1857 after considerable agitation. The fortunate result has been that the mining rights did not fall into private hands.

The estimated amount of the coal reserve of Nova Scotia is less than 1 per cent of the total reserve for Canada, but, because of the excellent quality of the deposits, their remoteness from other coal-fields, and their accessibility, Mr. Gray considers Nova Scotia will remain the chief coal-producing province of the Dominion for a long time. At present its output is nearly 60 per cent of that of the whole of Canada. One of the great difficulties in working the mines is caused by the ever-present gas, and in spite of all the precautions taken there have been several bad explosions resulting in loss of life.

Copious statistics of the various mines are given, and the excellent index provided renders reference to the report easy.

VI.—The Mining of Thin Coal Seams as applied to the Eastern Coal-fields of Canada. By J. F. Kellock Brown. pp. viii and 135, with figures and a coloured map. Department of Mines, Ottawa, 1917.

IT is well known that certain parts of the coal-fields of the eastern provinces of Canada contain a large number of thin seams of coal in addition to the thick ones which are more generally worked. The Government authorities have very wisely undertaken the consideration of how these may best be turned to account. The chief problem to be solved is to determine whether it is most advisable in the public interest to work all seams together, or to preserve either the thicker or the thinner seams with a view to keeping up the supply as long as possible. In this memoir the line of demarcation between a thick and a thin seam is taken at 3 feet: the lower limit of possible working under conditions likely to obtain in the immediate future is taken as 12 inches, in agreement with the views of the British Coal Commission. After a careful survey of the whole situation it is recommended that the thin seams should be worked concurrently with the thicker ones, in order to extend as far as possible the life of the latter, and that measures should also be taken to secure co-ordination in colliery-working generally, so as to reduce working costs and to prevent wasteful competition. A very complete account is given of the position and thicknesses of all known seams, together with their depth from the surface. From this it appears that by far the richest area is in Pictou County, Nova Scotia, where some of the seams run up to nearly 40 feet. Over the rest of the

coal districts the seams are much thinner, though often still considerable, and the total reserve is still large. Unfortunately a large part of the coal-fields lie under the sea, so that access is rendered more difficult.

R. H. R.

VII—Recent and Fossil Ripple-marks. By E. M. Kindle. Geological Survey of Canada, Museum Bulletin No. 25. pp. 56, with 33 plates. Ottawa: Government Printing Bureau, 1917.

RIPPLE-MARKS are of three distinct types: the first is due to current action on a sandy bottom, the second to wave action, and the third to the direct action of wind on sand. Mr. Kindle discusses very fully the characteristic features of each type, and illustrates them by means of photographs and profiles of casts of plaster of paris moulds taken directly from ripple-marks. Many of the moulds were actually taken under water, at times at not inconsiderable depths, with the aid of ingenious apparatus which the author had specially designed for the purpose. Geologists will be grateful to him for his clear exposition of the subject. For the lack of some such work geological literature contains many references to ripple-marks which are full of mistakes. A common error is to suppose that fossil ripple-mark is evidence of shore or shallow-water conditions. On the contrary, there is every reason to believe that the action of a storm wind will produce ripple-marks to a depth of at least fifty fathoms of water. The greatest depth at which the author has obtained a plaster of paris mould was 27 feet. Again, many of the so-called "mud-flows" which have often puzzled geologists are really the marks produced by the mutual interference of two or more currents.

It is interesting to note that whereas the amplitude of dune or wind ripple-mark shows only slight variation, that of subaqueous current ripple-mark may vary enormously, depending on the load of sediment carried and the velocity of the current. Ripples of colossal size are developed in the Ottawa River during the flood stage over the broad sand-bar at Duck Island. In late summer they are laid bare at low water, and the crests of the ridges are seen to be 30 to 45 feet apart and 1 to 2 feet above the troughs. In estuaries subject to strong currents terrace-like ripples are formed which though of remarkable size closely resemble ordinary ripple-marks.

VIII.—South Australia.

A Review of Mining Operations in the State of South Australia during the half-year ended December 31, 1916. No. 25. Compiled by L. C. Gee, S.M., Chief Registrar and Recorder, Department of Mines. pp. 91, with 4 plates and map. Adelaide, 1917.

THIS review contains reports on a number of different mining and prospecting operations in the State of South Australia. Bores have been undertaken with the object of discovering the westerly extension of the Wallaroo main lode to the Wallaroo Extended

Leases, unfortunately without good results, though they were continued through the old crystalline rock to a depth of over 1,000 feet in two cases. Among the special reports, accounts are given of the working of precious opal in Stuart's Range in the centre of South Australia, manganese ores at Pernatty Lagoon, boring for oil near Robe, and details of various copper-mines, most of which are not now working.

The precious opal occurs in the Desert Sandstone of Upper Cretaceous age, as it does in all the other opal-fields of Australia, which, like the Stuart's Range field, are all situated just inside the region, which has a rainfall of 15 inches per annum. It occurs in veins and patches associated with large amounts of common opal, and seems to have been formed in a similar manner to that in which surface quartzites and limestones are formed in similar dry regions. The amount of the precious variety is not large, but good finds are made. The Pernatty Lagoon manganese deposits seem to be a valuable field of this metal. The ore, which contains from 64 to 81 per cent of MnO_2, with a certain amount of ferruginous material, is associated with a dolomite of uncertain age, and is found generally along the master joints. A considerable quantity of ore has been raised, and more would be sent away but for difficulties of transport in a rainless country.

Near Robe a bore has been sunk to a depth of 3,950 feet in search of oil. The district was the subject of a report in the last review of mining operations (No. 24). In this report the Government Geologist reported very unfavourably on the oil prospects, and his conclusions seem to have been substantiated, since after passing through Tertiary limestone, with gravels and lignite, and Jurassic carbonaceous shales to the depth above-named no signs of oil have been seen, except a little natural gas. Of the copper-mines reviewed, some seem still to have good reserves of ore; many were abandoned owing to shortage of labour in the days of the gold rush in 1851, and not owing to failure of ore supplies. The present time, when the price of copper is so high, seems to be a favourable opportunity for restarting some of these concerns.

W. H. W.

IX.—North Queensland Tin-fields.

Geology and Mineral Resources of the Cooktown District Tin-fields (North Queensland, 1914). By E. Cecil Saint-Smith, A.S.T.C., Assistant Government Geologist, Queensland Geological Survey. pp. 211, with 3 maps, 4 figures, 59 plates, and 3 plans. Brisbane, 1916.

THE Cooktown district tin-fields are situated in a hilly region, about 36 miles long, along the east coast of Queensland, running south from Cooktown at the mouth of the Annan River. The country is composed of slates probably of Gympie (Permo-Carboniferous) age, invaded by large masses of granite, with a few flows of post-Tertiary basalt and alluvium of two different ages. The tin-ore is found in the alluvium, both old and new, and is disseminated through

the greisenized granite and associated with small veins of quartz and tourmaline in the neighbourhood of its contact with the slates. Lodes of any size are very rare, and tin-ore is never found in the slates themselves. With the exception of one or two mines, the ore is exclusively won in open works by sluicing the loose alluvial material or the granite in situ, where it has been deeply weathered (sometimes as deep as 100 feet) by the effect of the tropical climate. The mining, except in the case of the Wallaby Creek Company at Rossville, is on a very small scale, and the water power is provided by the local streams, which are led in channels to the site of the workings. As there is a very distinct wet and dry season these streams do not always contain water, so that the mining in some places is confined to the wet season. The Annan River Company, however, are working on a much larger scale, and have erected powerful pumping plant, so that they can rely on a constant supply of water from the lower reaches of the Annan River. This company between 1911 and 1914 raised over 146 tons of tinstone, worth over £17,000, and is the only large producer in the district with the exception of the China Camp group of mines further south, which produced in the same time 269 tons of ore.

The cassiterite is generally black in colour, but ruby and clear varieties are found in some localities. The only other mineral occurring in quantities which can possibly be regarded as payable is wolfram, of which one or two lodes are known, but this is in very small quantities.

The field bids fair to continue to produce tin for some long time to come, but will never be a large producer. The content of ore is never very great, being as a rule between 1½ and 2½ lb. to the cubic yard, but exists in great quantities, and is for the most part easily mined. Two factors interfere to some extent with the development of the field, one being the great cost of carriage of materials from Cooktown and the other the scrub-covered character of the country, which makes prospecting very difficult.

W. H. W.

X.—Minerals associated with the Crystalline Limestone at Crestmore, Riverside County, California. By A. S. Eakle. Bulletin of the Department of Geology, University of California, vol. x, pp. 327–60. Berkeley, 1917. Price 40 cents.

THIS paper is an interesting contribution to the study of the thermal metamorphism of limestones of varying composition. The limestone forms a mass resting on the upper surface of a mass of igneous rocks and penetrated by dykes. The igneous rocks comprise granodiorite, quartz-monzonite porphyry, and pegmatite. The total number of minerals described is about fifty, and it is clear that these may be divided into three categories, those formed by simple recrystallization of impurities in the limestone, those formed by diffusion into the limestone of material from the igneous magmas, and those belonging properly to the magmas. The limestone is for the most part fairly pure and has crystallized to a white marble,

often of very coarse texture, and containing some very remarkable masses of sky-blue calcite. The origin of this peculiar colour is unknown. The upper part of the limestone was apparently more dolomitic, and here brucite has been largely developed, often in association with graphite. In the contact zones, where diffusion of silica has taken place from the magma, the commonest minerals are wollastonite, vesuvianite, and garnet, with diopside and monticellite. Some supposed new minerals are described under the names of wilkeite, riversideite, and crestmorite; the analyses and description of these are not very convincing, and suggest mechanical mixtures of silicates and phosphates. In close association with the igneous rocks are also found axinite, scapolite, and datolite, which belong properly to pneumatolytic metamorphism. The chief interest of this remarkable occurrence lies in the fact that it seems to combine in itself nearly all the types of limestone metamorphism hitherto described. No indication is given of the age of the limestone or of the intrusions.

R. H. R.

XI.—The Ore Deposits in the Environs of Hanano-Yama, near the Town of Oda, Province of Nagato, Japan. By Takeo Kato. Journal of the Meiji College of Technology, vol. i, pp. 1–95, with 10 plates, 1916.

FROM an exhaustive study of the mining district of Oda, in the Province of Nagato, Japan, a district which has long attracted the interest of geologists and mineralogists because of the existence of contact-metamorphic ore deposits of diverse character and the occurrence of beautiful specimens of copper minerals—cuprite, native copper, malachite, and chrysocolla—and of various sulphides, silicates, and other contact minerals, Professor Kato draws some important conclusions with regard to certain of the problems confronting students of contact metamorphism. He considers that "iron, silica, various rarer metals, mineralizers, etc., i.e. the greater part of the elements composing the lime-silicate minerals and the entirety of ore-minerals of the contact metamorphic deposits, have been derived from the emanations from the magma".

Another important point is that the metamorphosing solutions first expelled from a consolidating acidic magma are siliceous in character, and are afterwards basic, becoming rich in iron, copper, and other metals, while still containing some silica; finally, at the end of the mineralization the solutions are rich in iron, copper, and sulphur, but contain little silica. The lime-silicates are therefore formed before the minerals rich in iron, and the sulphides and oxide-ores appear about at the same time as the andradite and hedenbergite. Although mineralization in contact metamorphic deposits begins with the magmatic intrusion and continues up to solidification of the entire mass, the formation of the main deposits is confined to the early—the pneumatolytic and pneumato-hydatogenetic—stages, while subsequently occur the hydrothermal alterations of the country rock and deposition of sulphide ores associated with quartz and calcite, but no lime-silicates. The paper is well illustrated.

XII.—Cretaceous Pelecypoda of Egypt.

Catalogue des Invertèbres de l'Égypte représentés dans les collections du Musée de Géologie au Caire. Par R. Fourtau. Terrains Crétacés. 2me Partie: Mollusques Lamellibranches. 4to; pp. viii + 109, pls. 7. Cairo: Geological Survey of Egypt, Palæontological Series, No. 3.

THE rich collections of Egyptian invertebrate fossils contained in the Museum of the Geological Survey of Egypt, at Cairo, have for some time past been submitted to Monsieur R. Fourtau for determination and description, with the result that three important monographs have now been published, elaborately illustrated by lithographic drawings designed by F. Gauthier, the preparation of which reflects the greatest credit on the author, and also on Dr. W. F. Hume, the Director of the Survey, under whom the work has been accomplished.

No. 1 of this series, issued in 1913, describing the Eocene Echinoidea, was reviewed in the Geological Magazine for that year, and No. 2, pt. i, devoted to the Cretaceous Echinoderms, was noticed in this journal for 1914. The present memoir, No. 3, forms the second part of the Cretaceous group of fossils.

The memoir figures and describes 170 different forms of Pelecypoda, Neumayr's classification being adopted with modifications from the works of Munier-Chalmas, Bernard, H. Douvillé, and Pervinquière, and the genera and families are arranged under the groups Taxodonta, Anisomyaria, Schizodonta, Heterodonta, Desmodonta, and Pachyodonta. Among the species referred to the following are regarded as new: *Leda perdita*, Conrad, var. *sinæa*, *Arca ægyptiaca*, *A. coquandi*, *Ostrea isidis*, *O. roachensis*, *Cardita roachensis*, *Lucina dowsoni*, *Siliqua humei*, and *Corbula peroni*.

Following the various descriptions, the author gives a good analysis of the studies of previous observers, and freely criticizes, when necessary, their determinations and nomenclature. He is of opinion that the name best known for a fossil should be preferred even if it be a *nomen nudum*, in illustration of which Zittel's *Pecten farafrensis* of 1883 may be noted. This fossil, except as a list-name, was without history so far as literature was concerned until 1898, when Mr. R. Bullen Newton described and figured *Pecten mayer-eymari*, from the Esna Beds of Egypt, which afterwards was acknowledged to be the equivalent of *P. farafrensis*; therefore the name of *P. mayer-eymari* must be adopted for the Zittelian shell, although German palæontologists have thought differently, Wanner having introduced the old *nomen nudum* in his memoir of 1902, which is now adopted by M. Fourtau.

In the introduction to his work the author presents us with his views on zoological nomenclature, from which the following may be quoted: "En ce qui concerne la nomenclature, j'ai estimé qu'en dépit de la loi de priorité, on ne saurait s'en prévaloir contre des dénominations peut-être moins anciennes, mais connues de tous et constituant pour le fossile une sorte de possession d'état-civil, que tous les codes civilisés reconnaissent aux personnes. Ces exhumations

de noms désuets ou inconnus parfois de tous, ne peuvent que jeter le trouble dans la nomenclature, et elles ne sont justifiées que lorsque le nom usité a été déjà préemployé pour une autre forme."

On similar grounds the genus *Roudairea*, of Munier-Chalmas, 1881, is adopted instead of Stoliczka's *Veniella* of 1871, which undoubtedly has priority. It may be pointed out, likewise, that the original orthography of *Arca esnaensis* has been altered, without comment, to *A. esnehensis*. We consider that the genus *Ostrea*, of which many species are discussed, would have added much to its distinctness if it had been divided up into the well-known genera of *Gryphæa, Exogyra, Alectryonia*, etc., although it may occasionally be difficult to place a species through slight overlapping of its characters.

The "Tableau Synoptique" furnishes a useful conclusion to this monograph in which the forms are listed in the order of description, together with their stratigraphical and geographical distribution. Four stages of the Upper Cretaceous are recognized, viz. Cenomanian, Turonian, Emscherian, and Aturian, while the occurrences are entered under Egypt, Sinai, and other countries.

It is hoped that many more parts of this "Palæontological Series" may be issued by the Geological Survey of Egypt, although in future memoirs we strongly recommend the addition of an alphabetical index of all the species and genera, wherever mentioned in the text, either as synonyms or otherwise.

There should be a great demand for this volume and those previously published, being indispensable to the student of Egyptian palæontology.

XIII.—Report on the Monazite Sand Deposits in Travancore. By I. C. Chacko, State Geologist. pp. 13. Trivandrum, 1917.

THE monazite sand deposits of Southern India have now become of considerable commercial importance, and the Government of Travancore has carried out a complete survey of all the known deposits within its territory. The country rock is mainly composed of charnockites and leptynites, overlain in places by the Warkalay beds, which are supposed to be Tertiary and equivalent to the Cuddalore sandstones of the east coast. The monazite is found in the sands of the seashore, which are black in colour, owing to the presence of much magnetite and ilmenite, together with garnet, rutile, apatite, and zircon. The total area covered by sands rich enough in monazite to be worked is estimated at 1,427 acres, calculated to contain about 17,000,000 tons of monazite. However, owing to tides, currents, storms, and floods, the total amount of sand seems to vary considerably from time to time. Some of the sand-dunes near the shore are also rich in monazite. The monazite is undoubtedly derived from the charnockite series: certain pegmatites are specially rich in this mineral, but it is probably widely disseminated in small quantity. It is believed that it has mainly passed from the old rocks to the coast deposits by way of the Warkalay beds and has been concentrated in the modern sands by the action of rivers and the waves of the sea. It is possible that

deposits formed in old lagoons may now be covered up by blown sands and silt: such places would probably repay investigation.

R. H. R.

XIV.—Annual Report of the State Geologist, Travancore, for the year 1091 M.E. pp. 21. Madras, 1917.

THIS report deals with the re-survey of the southern part of the State. The formations here found may be divided into the five following groups: (1) crystalline rocks, (2) laterites, (3) limestones, (4) the Warkalay formation, (5) the recent deposits. The crystalline rocks form part of the great charnockite series: they are on the whole intermediate in composition, containing little quartz. These typical fresh charnockites are overlain on the higher ground by a zone of leptynite, in which the felspar is kaolinized and the hypersthene converted into garnet. The massive charnockites are cut by numerous dykes of norite. The laterites are chiefly of the residual type formed from the crystalline rocks. The Warkalay beds are mostly coarse red and yellow sands, and the argillaceous formation known as teri probably forms part of this series, which is believed to be of Cretaceous age. The occurrence of monazite in the Warkalay and recent formations is dealt with in a separate report. The chief minerals of economic value, besides monazite, are graphite and pyrrhotite.

R. H. R.

XV.—Brief Notices.

1. Homœomorphy.—A clear exposition of homœomorphy as applied to fossil Corals will be found in a paper by W. D. Lang in the Proc. Geol. Assoc., xxviii (2), 1917. It forms the subject of a demonstration given to the members on the occasion of a visit to the British Museum (Nat. Hist.). Mr. Lang deals with—(1) Diagnostic characters of Corals in general and tests whereby fossil Corals may be known. (2) Homœomorphy in general and its meaning when applied to fossil Corals. (3) Cases of homœomorphy in Corals; homœomorphy between Corals and Polyzoa; between Corals of different formations, and between Corals from the same formation; among Alcyonarian Corals. (4) Connexion between homœomorphy and evolutionary stages in Corals; "Morphic Equivalence" of Buckman; Radicals. (5) Relationship of Rugose Corals and Hexacorals; homœomorphy in Jurassic Hexacorals. Altogether an admirably useful paper, to which the student can refer with advantage.

2. Varro on Soils.—It may be well to recall to those who work on soils the notes made by Varro in the first century B.C. in his *Rerum rusticarum*, of which a new translation was issued in 1912 in Bohn's Classical Library (G. Bell & Sons) by Lloyd Storr-Best. Chapter vi deals with the Soil, chapter vii the Site, and chapter ix Farm Land. In chapter vii occurs the following passage, so interesting to a geologist; Cn. Tremelius Scrofa is speaking: "When I was in command of an army in Transalpine Gaul—in the

interior near the Rhine—I came to several districts where neither vine, olive, nor fruit-tree would grow, where they manured the fields with 'marne' [*candida fossicia creta*], dug from the ground, where they could get salt neither by digging nor from the sea, but used instead of it salt charcoal, made of the burning of certain woods."

3. Fossil Insects from Florissant, Colorado. — This paper, by Mr. T. D. A. Cockerell (Proc. United States Nat. Mus., vol. liii, pp. 389–92, 1917), describes five new species of insects from the well-known Miocene shales of Florissant, but being without figures they are of little use to the palæontologist.

4. Minerals of Glamorgan.—Mr. F. J. North has issued a careful paper on the Minerals of Glamorgan in the Trans. Cardiff Nat. Soc., xlix, 1916. Some thirty species are recorded and fully described, with notes and information of local interest. Special attention is paid to economics, and the paper concludes with a bibliography. Gold in rounded grains is recorded from the Keuper Marl.

5. Tritylodon.—A recent examination of the skull of *Tritylodon longævus*, Owen, allows Dr. B. Petronievics to give as mammalian characters: divided roots of molar teeth, multituberculate teeth, straight and parallel rows of teeth, and no post-frontal bone; as reptilian characters: divided nares, pre-frontal bone, and frontal bone not bounding the orbit; while those characters both mammalian and reptilian are recorded thus: septomaxillary bones, terminal position of anterior nares, backward position of posterior nares, divergent parietals, orbito or alisphenoid (or orbitopalatine?), no postorbital bar, and brain-case antero-laterally closed. Some further preparation of the type skull by Mr. Barlow has enabled Dr. Petronievics to come to these conclusions, which he considers show *Tritylodon* to be a direct evidence that the mammals have their origin in reptiles, most probably in Theriodont Reptiles (Ann. Mag. Nat. Hist. [8], xx, October, 1917).

6. Folkestone Warren.—Despite the long literature on Folkestone Warren, it has been left to Mr. C. W. Osman (Proc. Geol. Assoc., xxviii (2), 1917) to approach the subject from a mechanical point of view and elucidate its structure from the recurring landslips, especially that of December, 1896. Studying the effect of compression on the Gault, the critical slope of Chalk on Gault, types of movements in the Warren, and the effect of water on those movements, he describes the cross sections and accounts for the origin of the Warren. Proceeding further, he measures up the Lower Chalk, discusses the effect of the Ferques axis on deposition, and gives the thickness of the Gault here and at various places in Kent. The paper is illustrated by a large-scale section from Folkestone to Dover, and sections at numerous points at right angles to the coast. A list of fossils collected from the Chalk Marl is provided by Mr. H. A. Allen.

REPORTS AND PROCEEDINGS.

I.—The Royal Society.

November 22, 1917.—Sir J. J. Thomson, O.M., President, in the Chair.

The following paper was read: "The Pelmatoporinæ, a Group of Cretaceous Polyzoa." By W. D. Lang, M.A., F.G.S. (Communicated by Dr. F. A. Bather, F.R.S.)

The evolution of this sub-family is considered in detail. In order to present the facts intelligently, they are marshalled according to the following theoretical considerations:—

1. The species lie along diverging lineages; towards the bases or proximal ends of these are forms (radicals) with less calcareous skeletal matter and less elaboration of structure, and these forms appeared earlier in geological time; towards their higher or distal ends are forms with more skeletal matter and more elaborate structure, appearing later in geological time.

2. The evolutionary tendency was to deposit the increasing superfluity of calcium carbonate where it least interfered with the organism's bionomics; if possible, in such position and shape as might even be useful to the organism. Sooner or later the race perished through being unable to cope with its constitutional and increasing habit of excessive secretion of calcium carbonate.

3. There is a predisposition in radical forms of different lineages to deposit their superfluous calcium carbonate along corresponding tracts and with it to build up similar secondary structures. They differ in comparative rate of building and in amount of elaboration, as well as in details in architecture and ornament. Consequently, (*a*) in most cases it is possible to predict the general history of a lineage from an examination of one of its early terms; and (*b*) lineages often present series of homœomorphic forms; while characters diagnostic of genera, and still more of congeneric lineages, often appear trivial and of little importance to the organism.

4. The "Law of Recapitulation" holds good in post-embryonic growth-stages, not only of the individual but of the colony as expressed by the individual constituents at successive distances from its starting-point. In fossil Polyzoa, astogeny (as Cumings called the development of the colony) is more easily observed than ontogeny.

5. Periodicity is displayed by the Pelmatoporinæ in their evolution.

The relations of the various forms are inferred from their adult morphology. Their stratigraphical distribution is considered in order to confirm these relations, though the evidence of stratigraphy can only be negative; it can contradict a supposed relation, but cannot affirm it. Finally, astogeny of forms is used to test morphological results.

Incidentally, results obtained by W. K. Spencer in his investigations on evolution of Cretaceous star-fishes are compared and found generally to correspond with results described in this paper.

II.—Edinburgh Geological Society.

1. *October* 17, 1917.—Professor Jehu, President, in the Chair.

"Sketches of South African Geology." By Professor S. J. Shand, D.Sc., Ph.D.

The major physiographic divisions of South Africa are the Coastal Plain, the Mountain Barrier, and the Interior Plateaux of the Karroo and the High Veld. The Coastal Plain on the west has a width of some 30 miles, rising gently from the sea-level to the foot of the mountains. Geologically it is formed of rocks of the Nama System (Cambrian or Pre-Cambrian), resting upon old metamorphic rocks, with numerous great granite intrusions. There is no continuous plain on the south coast, but there are many narrow shelves and patches of raised beach, testifying to recent movements of elevation. On the east side the Coastal Plain again becomes a continuous feature, reaching a great width in Portuguese East Africa, where, however, little is known of its geological structure. The Mountain Barrier of the west and south is the folded margin of the Interior Plateau, but on the east it is the fractured edge of the plateau; that is to say, the west and south coast ranges are fold mountains, while those of the east are fault mountains. The former are largely composed of the hard Table Mountain Sandstone, resting with a strong unconformity upon the Nama rocks. The age of the Table Mountain Sandstone is deduced from the fact that the overlying Bokkeveld beds yield trilobites, brachiopods, and lamellibranchs of Lower Devonian age. On the inner side of the Mountain Barrier the rocks of the Karroo System make their appearance and cover the greater part of the interior of the Sub-Continent. The lowest member of this system is the Dwyka Glacial Conglomerate, which extends from the South-West African Protectorate to Natal, and from the Transvaal to the south-west corner of the Cape Province. The higher members of the Karroo System have a more limited distribution than this, and the uppermost or Stormberg Series is restricted to the eastern districts, where it caps the Drakensberg Range. The close of the Karroo period was signalized by great igneous activity and diastrophism. The folded ranges were elevated at this time; the Karroo sediments were invaded by basic dykes and sills, and great outpourings of basaltic lavas took place in the regions of the Drakensbergen, the Victoria Falls, the Bushveld, and the Kaokoveld. The concluding event seems to have been the drilling of the kimberlite pipes, from which diamonds are now obtained. The deposition of the rocks of the Karroo System occupied the whole period from Carboniferous to early Jurassic time. Rocks younger than the Jurassic are only found in restricted areas along the south and east coasts, where there are patches of marine Cretaceous and Tertiary rocks.

As regards climate, South Africa shows four fairly distinct natural regions—one of summer rains in the east and central districts, one of winter rains in the south-west, a semi-arid region in the north and north-west, and an entirely desert area extending along the west coast roughly from the Orange River to Walvis Bay. This Coastal

Desert of the South-West African Protectorate has a rainfall of less than an inch per annum, and the strong southerly winds cause terrible sandstorms. Every exposed rock is cut and grooved by the sand-blast, and loose pebbles are faceted by the same agency and assume the forms known as *einkanter* and *dreikanter*. Wandering crescentic sand-dunes or *barchans* travel ceaselessly northward, covering up everything that gets in their way. In this inhospitable region diamonds are recovered from the sand by a number of German mining companies.

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2. *November* 21, 1917 (issued December 14, 1917).—Professor Jehu, President, in the Chair.

(1) "Descriptions of some new Volcanic Necks near Pittenweem." By D. Balsillie, B.Sc., F.G.S.

Immediately to the west of Pittenweem Harbour four small volcanic necks have been laid bare by the sea. The rocks among which these occur consist mainly of sandstones, shales, fireclays, and ironstones, along with a thin band of impure limestone yielding Entomostraca and *Spirorbis* that was estimated by Mr. Kirkby to be about 1,000 feet above the Encrinite-bed. The strata here dip a little to the north of west at high angles, and appear to have assumed such a disposition prior to their disruption by active volcanic forces.

The material filling the necks is in the main a non-volcanic sedimentary débris, but includes frequent pieces of a highly vesicular white trap. Neither is there discernible assortment of the constituents in any of these fragmentary accumulations, nor are alteration effects conspicuous. It appears probable, therefore, that we have here a record of only a transient manifestation of volcanic action.

(2) "The Glossopteris Flora." By D. Balsillie, B.Sc., F.G.S.

The apparently cosmopolitan floras of Upper Devonian and Lower Carboniferous times constitute, as emphasized by Seward, one great phase in the evolution of the plant kingdom. These floras included representatives of all the major classes of our present Pteridophyta, along with other types now entirely extinct or represented only by greatly diminished forms occasionally of the most restricted distribution.

Passing to Upper Carboniferous and Permian times, there is strong evidence to show that the earth's surface was then divisible into two great botanical provinces of ecological significance. In the northern hemisphere the vegetation might be regarded as merely a continuation of the older flora, but enormously amplified and extended. In the southern hemisphere, however, a totally new assemblage of types appeared, filicinean (pteridospermic?) mainly in the character of its foliage, and including as two characteristic genera *Glossopteris* and *Gangamopteris*. It is this great series of southern forms that has been designated the Glossopteris Flora.

Typical members of this southern flora have been recorded from

Permo-Carboniferous rocks in all the principal land areas of the southern hemisphere—India, Australia, South Africa, and South America. The obvious method of explaining this remarkable discontinuous distribution is to assume that there were at one time land connections between these areas, and, indeed some writers have gone so far as to suggest that there formerly existed a great east-and-west continent crossing the site of the present Indian Ocean. To this last continent Suess gave the name Gondwanaland.

Why should the vegetation of Gondwanaland have been peculiar? In explanation of this the author made reference to the Talchir rocks of India, the Bacchus Marsh conglomerates of Victoria, the Dwyka conglomerate of South Africa, and the Orleans conglomerate at the base of the Santa Catharina rocks in Brazil. All these strata, which are in intimate association with the plant-bearing beds, afford indisputable evidence of contemporaneous glacial action in late Palæozoic times. Geologists, therefore, believe that it was the secular climatic change accompanying this Permo-Carboniferous glaciation that impressed itself so remarkably upon the vegetation of Gondwanaland, extirpating the older lepidophytic types and giving birth ultimately to the Glossopteris Flora.

III.—Mineralogical Society.

Anniversary Meeting, *November* 6.—Dr. J. W. Evans in the Chair.

The following were elected Officers and Members of Council: President, Mr. W. Barlow, F.R.S.; Vice-Presidents, Professor H. L. Bowman, Mr. A. Hutchinson; Treasurer, Sir William P. Beale, Bart., K.C., M.P.; General Secretary, Dr. G. T. Prior, F.R.S.; Foreign Secretary, Professor W. W. Watts, F.R.S.; Editor of the Journal, Mr. L. J. Spencer; Ordinary Members of Council, Mr. T. V. Barker, Mr. G. Barrow, Professor C. G. Cullis, Mr. F. P. Mennell, Mr. H. Collingridge, Mr. T. Crook, Dr. G. F. Herbert Smith, Dr. H. H. Thomas, Mr. H. F. Collins, Mr. J. P. De Castro, Professor H. Hilton, Lieutenant Arthur Russell.

The following papers were read:—

Miss E. Smith: On Etched Crystals of Gypsum. Baumhauer conducted experiments on colemannite and calcite to determine whether the phenomenon of etched figures is due to lack of homogeneity or irregularity in the incidence of the dissolving liquid or to lack of homogeneity in the crystal itself. Further experiments now made on cleavage surfaces of gypsum tend on the whole to confirm Baumhauer's conclusion that the second hypothesis is the correct one.

Dr. G. T. Prior: On the Mesosiderite–Grahamite Group of Meteorites. Analyses of the mesosiderite Hainholz and the grahamite Vaca Muerta show that these meteorites do not differ materially as regards the amount of felspar, and microscopical examination of other mesosiderites supports the idea that there is no real distinction between them; the name mesosiderite is therefore proposed for the whole group. The groundmass of these meteorites consists mainly of anorthite and a pyroxene, poor in lime and having

a ratio of Mg O to Fe O of about 2. The iron and olivine are very unevenly distributed, and have chemical compositions such as they have in the pallasites, the iron being poor in nickel (ratio of Fe to Ni generally greater than 10), and the olivine poor in ferrous oxide (ratio of Mg O to Fe O from 6 to 9). In accordance with the author's conception of a genetic relationship of meteorites, it is suggested that a eucrite-like magma, i.e. one of higher oxidation, was invaded by a pallasite-like magma of lower oxidation. The curiously unequal distribution of the nickel-iron and the shattered (cataclastic) structure which is generally confined to the parts rich in iron support this view.

Professor H. Hilton: On Changing the Plane of a Gnomonic or Stereographic Projection. A method was described by means of which the gnomonic or stereographic projection of a crystal on any plane may be obtained when the projection on one plane is given. The application to the drawing or orthographic projection of the crystal was also discussed.

Professor H. Hilton: On Cleavage Angle in a Random Section of a crystal. A graphical method was given by means of which it is possible to calculate the chance that the angle between the cleavage-cracks on a random section of a crystal with two good cleavages may lie between specified limits. The method was worked out in detail for the cases in which the angle between the cleavage-planes was 90° or 60°.

IV.—Geological Society of London.

November 21, 1917.—Dr. Alfred Harker, F.R.S., President, in the Chair.

The following communication was read:—

"The Shap Minor Intrusions." By James Morrison, B.A., B.Sc. (Communicated by Dr. Herbert Lapworth, Sec. G.S., M. Inst. C.E.)

The paper deals with the minor igneous intrusions occurring in the triangular area between Shap, Windermere, and Sedbergh.

From their field relations and petrographic characters the intrusions are found to belong to one or the other of two well-marked groups, a division which is regarded as connoting also an age-classification.

The rocks of the earlier set, characterized by the presence of large orthoclase-felspars of the granitic type, are intimately associated with the granite, to the immediate neighbourhood of which they are practically confined. The rocks range from quartz-felsites to lamprophyres. Of considerable interest in this group is a series of hybrid intrusions, consisting essentially of rocks of a more or less basic magma enclosing xenocrysts of a more acid (but allied) magma obtained by settlement under intratelluric conditions. The constitution of any given member of the series is determined by two factors: the abundance of xenocrysts and the composition of the matrix, an increasing basicity in the latter (due to original magmatic differentiation) and a decrease in the former marking the successive stages. The more acid have affinities with the porphyrites, the more basic

with the lamprophyres, the series ranging from modified biotite-porphyrites to modified pilitic lamprophyres.

The later intrusions are typically free from the large orthoclase-felspars, though quartz-grains may occur even in the basic members. Associated centrally with the earlier set they are distributed over a much wider area, overlapping the former in every direction. They are the result of further differentiation, and are assigned to a later period when igneous activity was renewed on a more or less regional scale. The rocks include acid felsites and spessartites.

The rocks of the earlier set agree in general direction with the north-north-west fractures transverse to the strike of the country rock, while the later intrusions trend generally east of north.

V.—Geologists' Association.

December 1, 1917.—George Barrow, F.G.S., President, in the Chair.

The following lecture was delivered: "The Gold Coast." By Albert Ernest Kitson, F.G.S., Director of the Geological Survey of the Gold Coast.

The features to be considered, after a general description of the geography and tectonics of the colony, are: the Archæan gneisses, schists, amphibolites, etc., principally of the Eastern Provinces; the folded and zonally contorted pre-Cambrian, or early Palæozoic, altered sediments (conglomerates, quartzites, etc.), with interbedded volcanic rocks (rhyolite, andesite), flanking the former group and extending westward across the colony; deposits of gold and manganese.

Intrusions (into both groups) of granites, syenites, diorites, gabbros, etc.; dolerite volcanic necks; gold, tin, ilmenite, and molybdenite associated with these rocks.

The slightly inclined sedimentary rocks of the coast (with Devonian fossils) and of the greater part of Ashanti and the Northern Provinces with bauxites, oil-shales, and clays; the Tertiary deposits of Apollonia with bitumen and oil, the "laterites" and associated iron-ores. Fluviatile, estuarine, and æolian deposits.

The evidence of aboriginal occupation, consisting of stone-implement factories, camps, and crude forts, was also discussed.

CORRESPONDENCE.

WORM-BORINGS IN ROCKS.

Sir,—Dr. Bather's interesting communication on "Salt-weathering and supposed Worm-borings in Australia" (Geol. Mag., November, 1917) induces me to direct attention to a paper read by the late Duke of Argyll before the Royal Society of Edinburgh in January, 1889. In this he described similar tubes occurring in some of the quartzites of Sutherlandshire, and which he and the late Mr. Etheridge attributed to the burrowing of annelids. Some of these tubes were horizontal, having been drawn out of the vertical by movements due to shearing or slipping of the beds or laminæ of the deposit.

In a communication entitled "Pseudo-Scolites" (*Research*, April 1, 1889) I pointed out that such tubes or "foralites" might be seen in great numbers on sloping, sandy beaches, especially when the sand covers a deposit of shingle, and that they were simply vents formed in the wet sand by the escaping air, which was compressed by the advancing waves. In a given slope of shingle, covered with a layer of wet sand, there is a certain quantity of air, and this, on being compressed by an advancing wave, escapes through the wet sand at the surface. The advance of the wave increases the pressure, and the confined air escapes from the weakest points at the surface of the sand. From the vents thus produced the air issues with considerable energy, as bubbles forced through the water of a retreating wave often show. The receding tide leaves many of these miniature blow-holes intact, and frequently with a crater-like ridge of sand around their orifices. In some cases these tubes were 4 or 5 inches in depth, and on the more level parts of a beach where firm sand prevailed they were filled up with fine mud, Foraminifera, and minute fragments of shell, etc. Under favourable circumstances these tubes might be preserved from future obliteration.

Such tubes might also be formed in unindurated inland deposits by the escape of compressed gases caused by the decomposition of organic matter, chemical reactions, and by steam escaping from heated areas.

C. Carus-Wilson.

Altmore, Waldegrave Park,
Strawberry Hill.
November 13, 1917.

Note by Dr. Bather.

I must apologise for having omitted all reference to Dr. Carus-Wilson's previously published obervations, due, I regret to say, to pure ignorance of them on my part and presumably also on the part of Professor Högbom, with whose account they entirely agree. The pipe-rock of Sutherland is so well known to British geologists that it was hardly necessary for me to mention it. Dr. Carus-Wilson's reference to it is apparently intended to suggest that the horizontal position of some of the tubes in the Tasmanian rocks may be due to subsequent movement. On this point I have no evidence.

F. A. Bather.

BORING FOR COAL AT PRESTEIGN.

Sir,—The alleged discovery of buried stores of coal at the Presteign lime-kilns, suggested by Professor Watts (Geol. Mag., 1917, p. 552) as the origin of the local delusion that a bed of coal crops out there, is a possible explanation; but it is remarkable and lamentable that no tradition of the lime-burning survived among the unfortunate subscribers. Some such storing of fuel may account also for the local belief in the existence of coal at Cadwell, 3 miles E.N.E. of Presteign, where pieces of coal in the soil above a quarry in Wenlock mudstones and nodular limestones (containing the usual fossils) were visible in 1915. The coal may have been taken there to burn lime at some remote period.